DRAFT Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek

Covered parameters:

<u>East Fork Owyhee River</u>

Iron (total)
Phosphorus (total)
Total Suspended Solids
Turbidity
Temperature

<u>Mill Creek</u>

Cadmium (total)
Copper (total; dissolved)
Dissolved Oxygen
Iron (total)
pH
Phosphorus (total)
Temperature
Total Dissolved Solids
Total Suspended Solids
Turbidity

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Bureau of Water Quality Planning
Nevada Division of Environmental Protection
Department of Conservation and Natural Resource

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Executive Summary

Section 303(d) of the Clean Water Act requires each state to develop a list of water bodies that need additional work beyond existing controls to achieve or maintain water quality standards, and submit an updated list to the Environmental Protection Agency (EPA) every two years. The Section 303(d) List provides a comprehensive inventory of water bodies impaired by all sources. CFR (Code of Federal Regulations) 40 Part 130.7 require states to develop TMDLs (Total Maximum Daily Loads) for the waterbody/pollutant combinations appearing in the 303(d) List.

The East Fork Owyhee River (Wildhorse Reservoir to Mill Creek), first appeared on the 1996 303(d) list for total phosphorus, total dissolved solids (TDS), total suspended solids (TSS), turbidity and iron. In 1998, the lower reach of the East Fork Owyhee River (Mill Creek to Duck Valley Reservation) was added to the list for the same pollutants. The decision to include these water bodies on the 1996 and 1998 303(d) Lists were based upon data and information collected by NDEP. In 2002, the listing for the upper reach of the East Fork Owyhee River (Wildhorse Reservoir to Mill Creek) was expanded (based upon NDEP data) to include temperature. In 2002, Mill Creek was added to the 303(d) List due to exceedences of the cadmium (total), copper (dissolved and total), dissolved oxygen, iron (total), phosphorus, total dissolved solids, total suspended solids, temperature, turbidity and pH standards. Data collected by NDEP and corroborated by RTWG supported inclusion of these constituents into the 303(d) List for Mill Creek.

For each of these pollutants of concern, this report includes a discussion for the following categories:

- Problem Statement
- Source Analysis
- Target Analysis
- Pollutant Load Capacity and Allocation
- Future Needs

While the Rio Tinto Mine is a known contributor for several of the pollutants addressed in this document, there are other natural and human-caused sources within the watershed. For example, exceedances of the iron and phosphorus water quality standards are common throughout the entire state given that these constituents commonly occur in Nevada soils. Natural erosion in the watershed and the stream channel, and erosion from dirt roads, trails, mining activities, grazing, etc. can lead to increased levels of phosphorus, iron, total suspended solids and turbidity.

The TMDLs and load allocations presented in this report are in a form unique for Nevada. Through the use of equations, the defined TMDLs and load allocations vary with flow thereby addressing the EPA requirement to consider seasonal variations and critical flow conditions in the TMDL process.

This document presents a “phased” approach to the East Fork Owyhee River and Mill Creek TMDLs. A phased approach is used in situations where data and information needed to determine the TMDL and associated load allocations are limited. The phased or adaptive management approach enables states to use available information to establish interim targets, begin to implement needed controls and restoration actions, monitor waterbody response to these actions, and plan for future TMDL review and revision. As part of the phased approach, a number of future needs are identified for these waterbodies:

- A detailed source assessment including quantity, location, timing may be necessary for some of the identified pollutants of concern. A differentiation between natural and human-caused sources is needed for some pollutants.
- More detailed monitoring may be appropriate for certain constituents (dissolved oxygen, temperature) to verify that exceedances of the standards are actually occurring to an extent warranting concern.
- An evaluation of the appropriateness of "municipal or domestic supply" as a beneficial use for Mill Creek may be appropriate.
- Some of the water quality standards need to be reviewed and possibly revised to appropriate levels.
- As additional data are collected, update the linear regression relationship between total suspended solids and turbidity.

As time and resources allow, the Nevada Division of Environmental Protection will address these needs and update the TMDLs as appropriate.

DRAFT Total Maximum Daily Loads for East Fork Owyhee River and Mill Creek:

1.0 Introduction

Section 303(d) of the Clean Water Act requires each state to develop a list of water bodies that need additional work beyond existing controls to achieve or maintain water quality standards, and submit an updated list to the Environmental Protection Agency (EPA) every two years. The Section 303(d) List provides a comprehensive inventory of water bodies impaired by all sources. This inventory is the basis for targeting water bodies for watershed-based solutions, and the TMDL (Total Maximum Daily Load) process provides an organized framework to develop these solutions. CFR (Code of Federal Regulations) 40 Part 130.7 require states to develop TMDLs for the waterbody/pollutant combinations appearing in the 303(d) List.

The East Fork Owyhee River (Wildhorse Reservoir to Mill Creek), first appeared on the 1996 303(d) list for total phosphorus, total dissolved solids (TDS), total suspended solids (TSS), turbidity and iron. In 1998, the lower reach of the East Fork Owyhee River (Mill Creek to Duck Valley Reservation) was added to the list for the same pollutants. In 2002, the listing for the upper reach of the East Fork Owyhee River (Wildhorse Reservoir to Mill Creek) was expanded to include temperature. Mill Creek was added to the 2002 303(d) List due to exceedences of the cadmium (total), copper (dissolved and total), dissolved oxygen, iron (total), phosphorus, total dissolved solids, total suspended solids, temperature, turbidity and pH standards. This document presents TMDLs for these parameters (cadmium (total), copper (dissolved, total), dissolved oxygen, iron (total), pH, phosphorus (total), temperature, total dissolved solids, total suspended solids, turbidity).

1.1 Total Maximum Daily Load (TMDL) Defined

TMDLs are an assessment of the amount of pollutant a water body can receive and not violate water quality standards. Also, TMDLs provide a means to integrate the management of both point and nonpoint sources of pollution through the establishment of waste load allocations for point source discharges and load allocations for nonpoint sources. TMDLs are to be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with consideration given to seasonal variations and a margin of safety.

Once approved by the U.S. Environmental Protection Agency, TMDLs are implemented through existing National Pollutant Discharge Elimination System (NPDES) permits for point source discharges to achieve the necessary pollutant reductions. Nonpoint source TMDLs can be implemented through voluntary or regulatory nonpoint source control programs, depending on the state. In Nevada, the nonpoint source program is voluntary.

While each TMDL report is unique, many contain similar elements. Following is a discussion of the typical components that appear in TMDLs based upon EPA guidance (EPA, October 1999).

1.1.1 Problem Statement: The objective of the problem statement is to describe the key factors and background information that describes the nature of the impairment, such as chemical water quality, biological integrity, physical condition, etc.

1.1.2 Source Analysis: As part of a source analysis, the known loading sources (both point and nonpoint sources) are characterized by location, type, frequency, and magnitude to the extent possible. In the case of nonpoint sources, characterization activities can require significant financial resources.

1.1.3 Target Analysis: Section 303(d) (1) of the Clean Water Act states that TMDLs "shall be established at a level necessary to implement the applicable water quality standards." A purpose of the target analysis is to identify those future conditions needed for compliance with the water quality standards and for support of the beneficial use. According to the U.S. EPA (1999), one of the primary goals of target analyses are to clarify whether the ultimate goal of the TMDL is to comply with a numeric water quality criterion, comply with an interpretation of a narrative water quality criterion, or attain a desired condition that supports meeting a specified designated use.

1.1.4 Pollutant Load Capacity and Allocation: Another component is the identification of the waterbody loading capacity. The loading capacity is the maximum amount of pollutant loading a waterbody can assimilate without violating TMDL target. The allowable loadings are then distributed or "allocated" among the significant sources of the pollutant.

If appropriate, a margin of safety is included in the analysis to account for uncertainty in the relationship between pollutant loads and the water quality of the receiving water. It can also be stated that the margin of safety is to account for uncertainties in meeting the water quality standards when the target and TMDL are met. Additionally, consideration needs to be given to seasonal variations and critical conditions. The general equation describing the TMDL with the allocation and margin of safety components is given below:

$$\textit{TMDL} = \textit{Sum of WLA} + \textit{Sum LA} + \textit{Margin of Safety} \quad \textit{(Eq. 1)}$$

Where:

Sum of WLA = sum of wasteload allocations given to point sources
Sum of LA = sum of load allocations given to nonpoint sources

According to 40 CFR 130.2(i), TMDLs need not be expressed in pounds per day when alternative means are better suited for the waterbody problem.

1.1.5 Other Components: TMDL submittals often include a plan for TMDL implementation and for monitoring TMDL effectiveness. In Nevada, the TMDL is implemented through NPDES permits for point sources and through Nevada 319 Nonpoint Source Program for nonpoint sources of impairment.

1.2 A Phased Approach to TMDL Adoption and Implementation

This document presents a "phased" approach to the East Fork Owyhee River and Mill Creek TMDLs. A phased approach is used in situations where data and information needed to determine the TMDL and associated load allocations are limited. The phased or adaptive management approach enables states to use available information to establish interim targets, begin to implement needed controls and restoration actions, monitor waterbody response to these actions, and plan for future TMDL review and revision. Adaptive management or phased approach TMDLs are particularly appropriate to address nonpoint source issues. A phased approach enables the adoption and implementation of a TMDL while collecting additional information ("*Guidance for Water Quality Based Decisions—The TMDL Process*" (#EPA 440/4-91-001, April 1991)).

2.0 Background and Problem Statement

2.1 Study Area

The East Fork Owyhee River, a tributary of the Snake River, originates in northeastern Nevada and flows in a northwesterly direction through the Duck Valley Indian Reservation and into Idaho (Figure 1). Since 1938, the flow of the East Fork Owyhee River, has been regulated by Wild Horse Reservoir (Moore and Eakin, 1968). Irrigation is the primary water usage in the watershed with about 3,000 to 4,000 acres irrigated upstream of the Duck Valley Indian Reservation (NRCE, 1992). Mill Creek is one of several tributaries of the East Fork Owyhee River and is located about 1.5 miles south of Mountain City in northwest Elko County. The creek is approximately 1.44 miles in length and flows easterly to the confluence of the East Fork Owyhee River. Land uses in the watershed (above Duck Valley Indian Reservation have included grazing, irrigation, recreation, and mining, with primary landownership including U.S. Forest Service, Bureau of Land Management and private.

2.1.1 Active Dischargers Within East Fork Owyhee River and Mill Creek: A survey of the Nevada Bureau of Water Pollution Control's permits database, indicates that no NPDES (National Pollutant Discharge Elimination System) permits have been issued for point source discharges to the East Fork Owyhee River or Mill Creek. However, a temporary permit and an active groundwater discharge permit were identified and are listed in Table 1. Currently, remediation activities are underway to mitigate water quality problems resulting from runoff from the tailings piles. The "rolling stock" permit allows for construction equipment to enter the Mill Creek channel as needed to construct identified structures for improved site stability and tailings impoundment at the abandoned Rio Tinto mine site.

Table 1. Active Discharges within the East Fork Owyhee River and Mill Creek

Permit Number	Permittee	Facility Type	Discharge
TNEV 2000410	Rio Tinto Working Group	Construction (Rolling Stock)	Mill Creek
NEV 40023	Mountain City, NV	Municipal Wastewater Treatment	Groundwater

Source: Nevada Bureau of Water Pollution Control files

2.1.2 Rio Tinto Mine and its Impact on Water Quality: Acid mine drainage and groundwater contamination from the Rio Tinto mine, has adversely impacted the water quality of Mill Creek and the East Fork Owyhee River. The mine site is located approximately 2.5 miles south of Mountain City, Nevada, within the Mill Creek drainage basin. Mining activity in the Mountain City-Patsville-Owyhee area dates back to the 1860's and 1870's, when gold, silver and copper deposits were discovered. The deposits were worked with considerable success until the ore bodies were depleted in the mid 1890's.

In 1931, a very rich and unusually shallow copper sulfide deposit was discovered in the Mill Creek-Mountain City-Patsville area. The ore body assayed an amazing 40% copper with the main ore body occurring at a depth of only 250 feet. The site was named Rio Tinto after the great Spanish copper deposit of the same name, by its entrepreneurial founder and promoter, Samuel Franklyn Hunt. Hunt quickly formed the Rio Tinto Mining Company and surprisingly sold 2 million shares of stock even before sinking the first shaft.

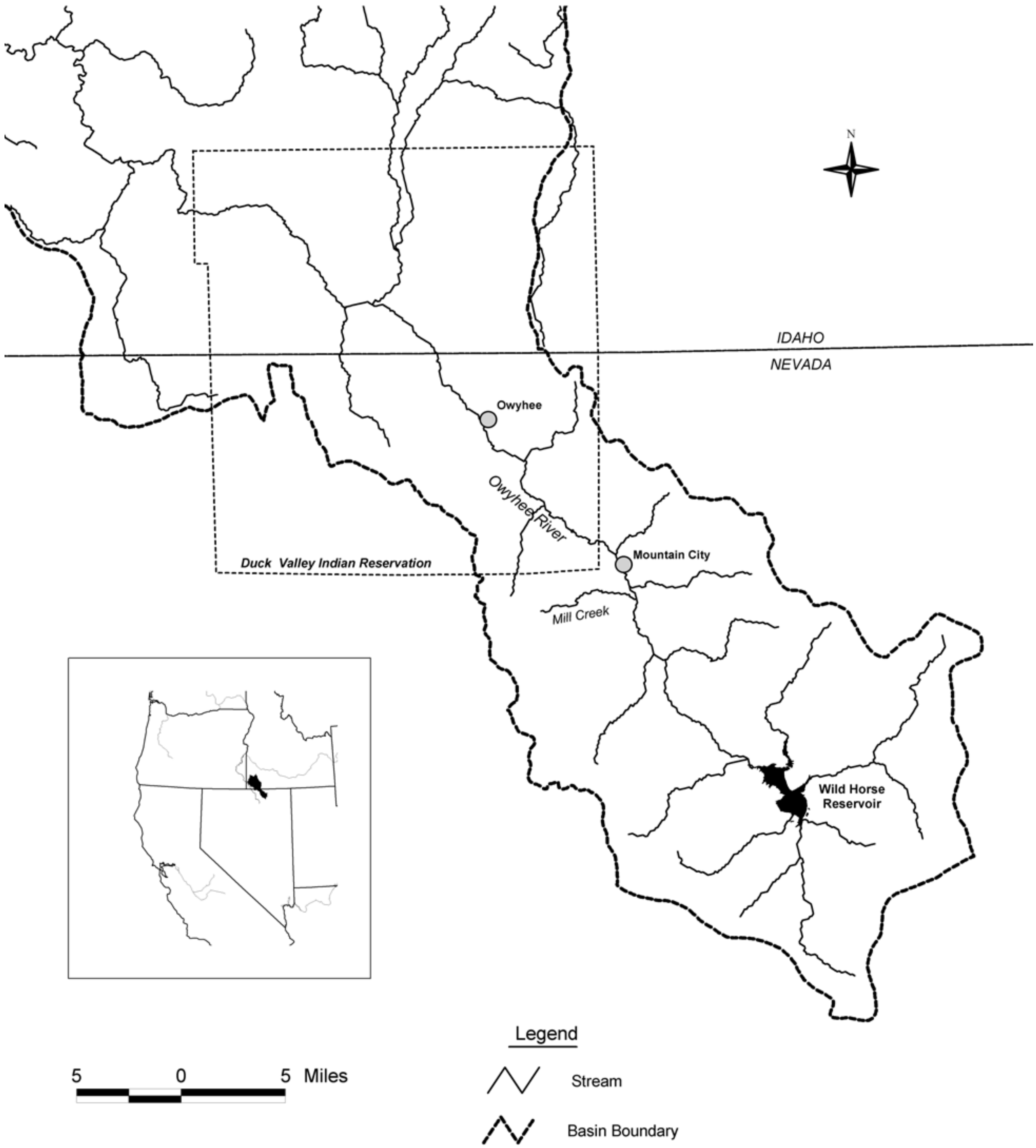


Figure 1. East Fork Owyhee River and Mill Creek Location Map

Seizing an unbelievable opportunity, International Smelting and Refining Company, a subsidiary of the Anaconda Mining Company purchased the property in June 1932 and in the process creating a new subsidiary company, the Mountain City Copper Company, for the purpose of operating the mine. Under Anaconda's leadership and financial support, the underground workings were expanded and a milling and flotation plant constructed on site. In addition, several impoundment ponds were constructed and Mill Creek was rerouted to its current location. Mining would continue at the Rio Tinto site until the high-grade ore deposit was depleted, some fifteen years later.

In 1947, Anaconda sold the property to a group of local individuals from Elko County, Nevada, where it would remain until 1966. It is uncertain if any activity took place at the mine during this period. However, during the 1950's, a considerable amount of uranium exploration activity occurred throughout the Mountain City Mining District, this in response to the Nation's newfound interest in nuclear power. Exploitable pockets of uranium ore were identified throughout the Mining District; however, no additional site development work was ever performed. The property was sold again in 1966 to the G.M. Wallace and Company, who with Cliffs Copper Corporation (a subsidiary of Cleveland-Cliffs Iron Ore Company) operated an acid heap leaching operation for metals recovery from the mine tailings. A disagreement between the two partners resulted in Cliffs Copper gaining full control of the property in 1967. Cliffs continued to run the in-situ acid leaching operation and began an in-situ acid leaching operation of the underground workings. Metals were recovered from the pregnant leach solution by precipitation. By adjusting leach solution pH with sodium hydroxide, sodium carbonate or calcium carbonate, it is possible to preferentially recover metals from solution. Significant amounts of waste sludge generated during the precipitation process were added to the tailings for disposal. This could account for the massive quantities of iron hydroxide present in the tailings.

The Rio Tinto property was sold to Cominco America, Inc. in 1972, with Cliffs Copper remaining as the mine operator. The last year of any significant mining activity was 1975 when Cliffs Copper removed the acid leach treatment plant and began stabilization of the tailings ponds in accordance with a closure plan approved by EPA. Stabilization included construction of a bypass ditch on the north side of the impoundment ponds in an effort to intercept surface and groundwater flowing into and through the ponds, the destruction of two tailings dams and the re stabilization of the already diverted Mill Creek. Northern Nevada's gold exploration boom during the 1970's generated a renewed interest in the Rio Tinto site. In partnership with Conoco, Cominco America undertook an exploratory drilling program with little success. Both companies later sold their interests to private individuals in 1978, which later sold their interests to a newly formed Rio Tinto Copper Company (not to be confused with the original company in 1986. Elko County obtained the site in 1987, due to non-payment of property taxes and subsequently sold the property at auction to a private individual, where it remains today.

Past mining and metal recovery activities, combined with the effects of the harsh Northeast Nevada climate, have contributed to the seepage and discharge of contaminated waters from the Rio Tinto site. These waters enter Mill Creek and surrounding waterbodies, eventually migrating to the East Fork Owyhee River. In addition, groundwater contamination, brought about collapsed underground workings and poor solution mining practices, has also contributed to the deterioration of the Creek and River's water quality (Lewis, May 1993).

Beginning in the mid-1990s, the Rio Tinto Working Group (RTWG), was formed to address the environmental problems of the mine site. The RTWG includes the corporate descendents of those companies once involved in all facets (i.e. exploration, mining and milling) of the activities performed at Rio Tinto. Active participants of the RTWG include the Atlantic Richfield Company (parent of Anaconda), Cleveland-Cliffs Iron Company (parent of Cliffs Copper), E.I. DuPont de Nemours and Company (parent of Conoco), and Cominco American Inc. Remediation activities at Rio Tinto began in the mid-1990s and have continued in the midst of debates over whether the U.S. Environmental

Protection Agency should declare Rio Tinto a Superfund site (Las Vegas Review-Journal, October 2, 2000). In the interim, an understanding regarding the future remediation of the Rio Tinto site and how these activities will be conducted was compiled and agreed upon. In an Administrative Order of Consent, issued on September 21, 2001, responsibilities of the RTWG regarding site remediation and cleanup were delineated and agreed upon by NDEP. A notable feature of this document is the development of a site conceptual model for improved site characterization; identify pollutants of concern and pollutant pathway determination. Once the validity of the site conceptual model is proven, remediation strategies can be developed, alternatives identified and finally implemented.

2.2 Water Quality Standards

Nevada's water quality standards, contained in the Nevada Administrative Code 445A.119 – 445A.225, define the water quality goals for a waterbody by: 1) designating beneficial uses of the water; and 2) setting criteria necessary to protect the beneficial uses. Beneficial uses include such things as irrigation, recreation, aquatic life, fisheries, irrigation and drinking water. The designated beneficial uses for the East Fork Owyhee River include:

- Irrigation
- Watering of livestock
- Recreation involving contact with the water
- Recreation not involving contact with water
- Industrial supply
- Municipal or domestic supply or both
- Propagation of wildlife
- Propagation of aquatic life

Numeric standards for the East Fork Owyhee River can be found in NAC 445A.144 *"Standards for Toxic Materials Applicable to Designated Waters",* NAC 445A.222 *"Owyhee River: East Fork above Mill Creek"*, NAC 445A.223 *"Owyhee River: East Fork south of Owyhee"* and NAC 445A.224 *"Owyhee River: East Fork Nevada-Idaho state line".* Currently, Nevada has not set specific water quality standards for Mill Creek. However, pursuant to NAC 445A.145 "*Control Points: Prescription and Applicability of Numerical Standards for Water Quality; Designation of Beneficial Uses"(e.g." Tributary Rule")*, surface waters upstream from the control point or to the next upstream control point or to the next water named in NAC 445A.123, are subject to the standards at the control point where the standards are specified. Because of this "Tributary Rule", Mill Creek is subject to the beneficial use water quality standards stated in NAC 445A.223, established at the control point located at the confluence of the Creek and River.

The numeric standards for the toxics cadmium, copper and iron are summarized in Table 2 and include concentrations associated with both the "dissolved" and "total" components, if applicable, and the designated beneficial use. The numeric standards for phosphorus, total dissolved solids, total suspended solids, turbidity, temperature and pH are summarized in Table 3 and the designated beneficial use.

The Shoshone-Paiute Tribes of the Duck Valley Reservation are currently in the process of developing water quality standards for the EF Owyhee River within the Duck Valley Reservation. The East Fork Owyhee River-Mill Creek TMDL will only address those portions outside the reservation boundary.

Table 2. Cadmium, Copper and Iron Standards for East Fork Owyhee River and Mill Creek[1]

Parameter		Beneficial Use	Numeric Standard (μg/l)	Comments
Cadmium	Total	Municipal or Domestic Supply	5	
		Irrigation	10	
		Watering of Livestock	50	
Copper	Dissolved	Aquatic Life 1-hour average	$0.85*e^{(0.9422*\ln(H)-1.464)}$	If Hardness = 50 mg/l, Standard = 8 μg/l If Hardness = 200 mg/l, Standard =29 μg/l
		Aquatic Life 96-hour average	$0.85*e^{(0.8545*\ln(H)-1.465)}$	If Hardness = 50 mg/l, Standard =6 μg/l If Hardness = 200 mg/l, Standard =18 μg/l
	Total	Irrigation	200	
		Watering of Livestock	500	
Iron	Total	Aquatic Life	1,000	
		Irrigation	5,000	

[1]Source: NAC 445A.144

e = 2.718, H = Hardness as $CaCO_3$ mg/l

Table 3. Dissolved Oxygen, Total Phosphorus, Total Suspended Solids, Turbidity and Temperature Standards for East Fork Owyhee River and Mill Creek

Parameter	Beneficial Use	Numeric Standard (°C, mg/l or NTU)	Comments
Dissolved Oxygen	Aquatic Life	> 6.0 mg/l	
Total Phosphorus	Aquatic Life	≤ 0.10 mg/l	
Total Dissolved Solids	Municipal or Domestic Supply	≤ 500 mg/l	
Total Suspended Solids	Aquatic Life	≤ 25 mg/l	
Turbidity	Aquatic Life	≤ 10 NTU	
Temperature	Aquatic Life	< 7°C	November - April
		< 21°C	May - October
pH	Aquatic Life	Between 6.5 and 9.0	

Source: NAC 445A.148.

2.3 303(d) Listing

The East Fork Owyhee River (Wildhorse Reservoir to Mill Creek), first appeared on the 1996 303(d) list for total phosphorus, total dissolved solids (TDS), total suspended solids (TSS), turbidity and iron. In 1998, the lower reach of the East Fork Owyhee River (Mill Creek to Duck Valley Reservation) was added to the list for the same pollutants. The decision to include these water bodies on the 1996 and 1998 303(d) Lists were based upon data and information collected by NDEP. In 2002, the listing for the upper reach of the East Fork Owyhee River (Wildhorse Reservoir to Mill Creek) was expanded (based upon NDEP data) to include temperature.

In 2002, Mill Creek was added to the 303(d) List due to exceedences of the cadmium (total), copper (dissolved and total), dissolved oxygen, iron (total), phosphorus, total dissolved solids, total suspended solids, temperature, turbidity and pH standards. Data collected by NDEP and corroborated by RTWG supported inclusion of these constituents into the 303(d) List for Mill Creek.

2.4 Water Quantity and Quality

2.4.1. Primary Monitoring Stations: Table 4 provides a list of the primary stream flow gauging stations and water quality monitoring stations in the East Fork Owyhee River basin (Figure 2). Data collected at these stations were the primary source of flow and water quality information utilized in the development of this report. Detailed water quality data is presented in the appendix.

Table 4. List of Selected Water Quantity and Water Quality Monitoring Stations for East Fork Owyhee River and Mill Creek

ID	Description	Agency	Period of Record
Stream flow Gauging Stations			
13174000	Wildhorse Reservoir near Gold Creek, NV	USGS	1938-96 (Discontinued)
13174500	EF Owyhee River near Gold Creek, NV	USGS	1936-Present
13175100	EF Owyhee River near Mountain City, NV	USGS	1991-95, 1997-Present
13176000	EF Owyhee River above China Diversion Dam near Owyhee, NV	USGS	1939-84 (Discontinued)
Water Quality Monitoring Stations			
E13	Wildhorse Reservoir at Pier	Nevada	1996-Present
E12	EF Owyhee River below Wildhorse Reservoir	Nevada	1996-Present
E4	EF Owyhee River above Mill Creek	Nevada	1979-Present
SW-3	EF Owyhee River above Mill Creek	RTWG	1995-Present
E14	Mill Creek near Patsville, NV	Nevada	1997-Present
SW-2	Mill Creek below Rio Tinto Mine	RTWG	1995-Present
E15	EF Owyhee River below Mill Creek	Nevada	2000-Present
SW-4	EF Owyhee River below Mill Creek	RTWG	1995-Present
E16	EF Owyhee River below Slaughterhouse Creek	Nevada	2000-Present
E3	EF Owyhee River below China Dam	Nevada	1989-1999 (Discontinued)
E2	EF Owyhee River at Boney Lane	Nevada	1989-1999 (Discontinued)

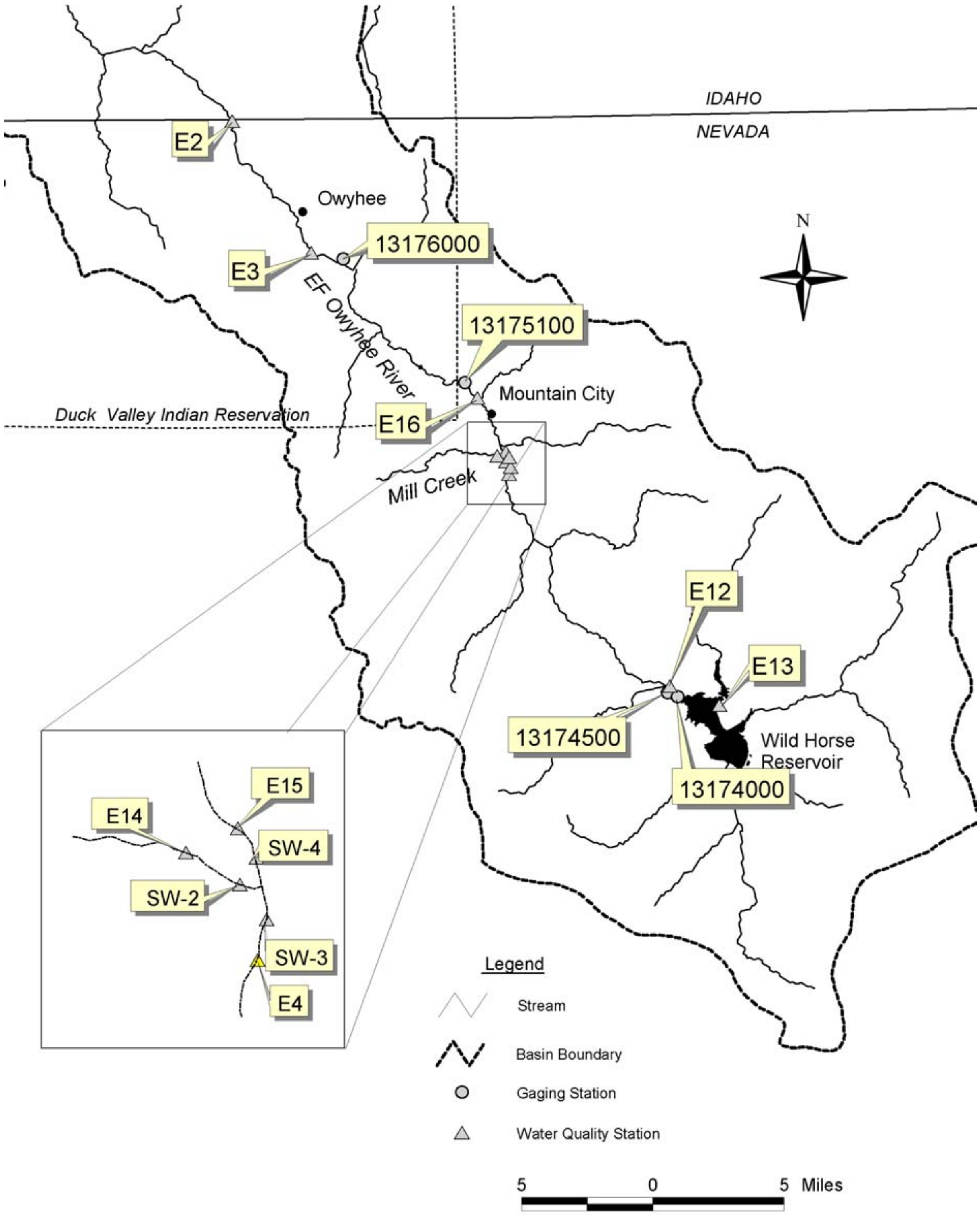


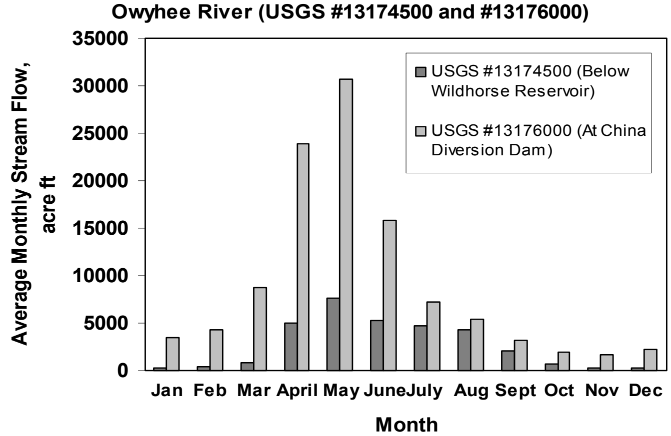
Figure 2. Selected Water Quantity and Quality Monitoring Stations for East Fork Owyhee River and Mill Creek

***2.4.2. Water Quantity**:* Surface water in the East Fork Owyhee River and Mill Creek is comprised primarily of direct runoff from rainfall and snowmelt. As shown in Figure 2 and presented in Table 4, two active USGS Stream Flow Gauge stations (#13175100 and #13174500) are located on the East Fork Owyhee. Station #13175100 is located outside the eastern boundary of the Duck Valley Reservation while Station #13174500 is located below Wildhorse Reservoir near Gold Creek.

Flow in the East Fork Owyhee River is regulated by the Wild Horse Reservoir with an average annual flow of about 32,000 acre-feet per year (AFY) immediately below the reservoir (USGS Station 13174500). With a drainage area above this location of about 209 square miles, the average annual yield for this sub basin is about 153 acre-feet / square mile. Several tributaries flow into the Owyhee River, the largest of those between Wild Horse Reservoir and Mountain City. At USGS flow monitoring station #13176000, which is located approximately 2 miles Southeast of Owyhee, on the Duck Valley Indian Reservation, average annual flows increase to 108,000 acre-ft/year. The average annual yield for the watershed at this location is about 236 acre-feet per square mile (based upon drainage area of 458 square miles).

Figure 3 shows average monthly flow data for USGS flow gauge #13176000 (East Fork Owyhee at China Diversion Dam, 1939 through 1984) and USGS flow gauge #13174500 (East Fork Owyhee at Wildhorse Reservoir, 1916 through 2001). At the China Dam gauge, April, May and June are high flow months (e.g. flows greater than 10,000 acre-ft/month) with the May exhibiting the highest average monthly flow at 30,669 acre-ft/month. At the Wildhorse Reservoir gauge, April through August are high flow months (e.g. flows greater than 5,000 acre-ft/month) with the May exhibiting the highest average monthly flow (7,693 acre-ft/month).

Figure 3. Average Monthly Stream Flow--East Fork Owyhee River (USGS #13174500 and #13176000)



2.4.3. Water Quality: As discussed earlier, the East Fork Owyhee River is included on Nevada's 2002 303(d) List due to exceedences of the total phosphorus, total iron, totals suspended solids, turbidity and temperature standards necessary for the propagation of aquatic life. In addition Mill Creek is included on Nevada's 2002 303(d) List due to exceedences of the above standards as well as total cadmium, total and dissolved copper, total dissolved solids, pH and dissolved oxygen. Existing water quality is discussed in greater detail in *Section 3.0 Total Maximum Daily Loads (TMDL).*

3.0 *Total Maximum Daily Loads (TMDL)*

3.1 *Cadmium (Total) TMDL*

3.1.1 Problem Statement: Table 5 summarizes total cadmium data as collected by NDEP and RTWG for Mill Creek. An evaluation of the data show that exceedances of the most restrictive total cadmium standard (0.005 mg/l) frequently occurred in Mill Creek but no exceedances were identified in the East Fork Owyhee River. Most of the cadmium in the water column appeared in the dissolved form.

All of the cadmium exceedances occurred during NDEP's late sampling (September) with most of the cadmium loads occurring in the dissolved form. During higher runoff periods, the cadmium levels are below the water quality standard.

Table 5. NDEP and RTWG Total Recoverable Cadmium Water Quality Standards and Historic Data for Mill Creek (mg/l)

Parameter	Mill Creek (SW-2)	Mill Creek (E14)
Period of Record	1995-2001	1997-2001
No. of Samples	6	13
NAC Standard 0.005 mg/l	NAC 445A.144 Standards For Toxic Materials Applicable To Designated Waters – for Municipal or Domestic Supply	
% of Samples Exceeding Standard	17%	31%
Average	0.0036	0.006
Median	0.0028	0.002
Minimum	0.0010	0.001
Maximum	0.0100	0.019

Values reported as less than detection limit are not included in average, median, minimum and maximum

Based upon NDEP's data for 1997-2001, Mill Creek was placed on the 2002 303(d) List for total cadmium. Note that between 1996 and 2001, RTWG did not analyze for total recoverable cadmium. Beginning in 2002, RTWG began analyzing for total recoverable cadmium.

3.1.2 Source Analysis: The Rio Tinto Mine is a known contributor to cadmium levels in Mill Creek. However natural sources may also be possible, but identifying off-site sources and pathways of cadmium impairment for Mill Creek is difficult at this time. Cadmium is not a common rock and soil constituent, however it is often associated with copper sulfide minerals, usually as a copper cadmium sulfide or alone as cadmium sulfide. Significant concentrations of these copper sulfide minerals are found throughout the Mountain City-Pattsville-Owyhee area in addition to the Rio Tinto site.

As ground and surface waters percolate through rock cracks and fissures within these deposits, some of the exposed sulfide minerals present will preferentially dissolve, resulting in an increase in acidity of the water. With this increase in acidity, additional sulfide minerals are exposed and dissolved. These acidic metal laden waters eventually migrate to Mill Creek. Furthermore, a significant portion of the mining activity at Rio Tinto occurred during a time when mine waste discharge regulations were almost non-existent. It was common practice for mine operators to discharge process residues, tailings and overburden into nearby rivers and creeks. This practice was known to have occurred at the Rio Tinto site, possibly contributing to the Creek's impairment.

Between 1966 and 1975, sludge material from the metals recovery process was routinely discharged into the Rio Tinto tailings impoundment area. This material contained appreciable amounts of iron, cadmium, copper, etc. in the form of metal hydroxides. As acidic mine waters came in contact with the sludge material, the metal hydroxides were re-dissolved and eventually transported to Mill Creek. The presence of cadmium in the sludge can be attributed to the fact that metal recovery from solution by pH adjustment does not make a fine separation, cadmium will precipitate out of solution as a complex cadmium hydroxide over a wide pH range between 4.5 and 11.5. In addition, cadmium shows an affinity for iron compounds at a pH between 3.0 and 8.0.

3.1.3 Target Analysis: As discussed earlier, NAC 445A.144 sets 5 μg/l as the allowable total recoverable cadmium concentrations in Mill Creek. This standard has been set at a certain level as needed to ensure continued support of the associated beneficial use, being municipal or domestic water supply. While Mill Creek is not currently used as a drinking water source, "municipal or domestic water supply" has been identified as one of its designated or potential beneficial uses. As such, NAC 445A.144 criteria still apply. For the purposes of this TMDL, the total cadmium target has been set at 5 μg/l.

The cadmium standard of 5 μg/l coincides with EPA's cadmium MCL (Maximum Contaminant Level) under the Safe Drinking Water Act. EPA has found cadmium to potentially cause the following health effects when people are exposed to it at levels above the MCL for relatively short periods of time: nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure. Additionally, cadmium has the potential to cause the following effects from a lifetime exposure at levels above the MCL: kidney, liver, bone and blood damage.

3.1.4 Pollutant Load Capacity and Allocation: The total cadmium Load Capacity or TMDL for Mill Creek (for any given flow) is represented by the following equation:

TMDL (lbs/day) = Water Quality Target x Flow x 5.39 (Eq. 2)

Where:

Water quality target = 0.005 mg/l
Flow = streamflow at water quality monitoring site
5.39 = conversion factor

This TMDL applies to any site on Mill Creek. While no continuous flow measurements occur on Mill Creek, RTWG has been taking streamflow measurements to coincide with the water quality sampling.

It is recognized that major cadmium loading is coming from a variety of sources within the Rio Tinto Mine site and downstream areas. Therefore, a gross load allocation that accounts for all these sources has been set and is represented by the following equation:

Load Allocation (lbs/day) = TMDL (lbs/day) (Eq. 3)

No explicit margin of safety is needed in this equation. As previously discussed, TMDLs are to include a margin of safety to account for uncertainties in meeting the water quality standards when the target and TMDL are met. Through Equation 2, the TMDL is directly related to the water quality standard with no uncertainty in this relationship. While there is uncertainty in the flow data, this uncertainty impacts both sides of Equation 2 equally.

The TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished through the use of the above equations whereby seasonal affects and critical conditions can be considered.

In some instances, TMDL reports present estimates of load reductions needed for compliance with the load allocations. However, this is not plausible for the Mill Creek TMDL. There are insufficient data to accurately calculate historic loads and associated load reductions. However it can be stated that for TMDL compliance, load reductions are needed such that actual loads are at or below the Load Allocation (from Equation 3) at least 90% of the time[1]. In the absence of flow data, the TMDL is considered to be complied with when the cadmium levels are below the target (0.005 mg/l) at least 90% of the time.

3.1.5 Future Needs: Following are future needs that have been identified for the phased cadmium TMDL and related activities:

- The appropriateness of "municipal or domestic supply" as a beneficial use for Mill Creek is questionable. Mill Creek is not currently used as a municipal or domestic drinking water source and its potential for that use is limited given the impacts of Rio Tinto Mine. BWQP may need to consider undertaking a Use Attainability Analysis for this use on Mill Creek.

- While Mill Creek has not been listed for dissolved cadmium, the levels are of sufficient magnitude to warrant continued monitoring. Additionally, the current dissolved cadmium standards are outdated and need to be revised based upon the most EPA guidance (1999).

3.2 Copper (Total and Dissolved) TMDL

3.2.1 Problem Statement: Tables 6 and 7 summarize total and dissolved copper data as collected by NDEP and RTWG on Mill Creek and show the frequency of exceedance of the water quality standards. Based upon NDEP's data, Mill Creek was included on the 2002 303(d) List for copper. These data show that exceedances of the total and dissolved copper beneficial use standards are very common and occur throughout the year under different flow regimes. However, the highest levels have generally occurred during the summer and late summer. The monitoring data did not indicate any standard exceedances on the East Fork Owyhee River.

Table 6. NDEP and RTWG Total Recoverable Copper Water Quality Standards and Historic Data for Mill Creek (mg/l)

Parameter	Mill Creek (SW-2)	Mill Creek (E14)
Period of Record	1995-2001	1997-2001
No. of Samples (Total Copper)	32	13
NAC Standard 0.20 mg/l	NAC 445A.144 Standards For Toxic Materials Applicable To Designated Waters – for Irrigation Uses	
% of Total Copper Samples Exceeding Copper Standard	97%	77%
Average	1.00	1.570
Median	0.30	0.400
Minimum	0.05	0.138
Maximum	5.13	7.500

Values reported as less than detection limit are not included in average, median, minimum and maximum

3.2.2 Source Analysis: The Rio Tinto Mine is a known contributor to copper in Mill Creek. However some natural sources may also be possible, but identifying off-site sources and pathways of copper for Mill Creek is difficult at this time. A once active copper mining district, marginal and low-grade copper sulfide and copper iron sulfide deposits can still be found throughout the Mountain City-Pattsville-Owyhee area.

[1] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

Table 7. NDEP and RTWG Total Dissolved Copper Water Quality Standards and Historic Data for Mill Creek (mg/l)

Parameter	Mill Creek (SW-2)	Mill Creek (E14)
Period of Record	1995-2001	1997-2001
No. of Samples (Dissolved Copper)	**32**	8
NAC Standard Dependent on Hardness	NAC 445A.144 Standards For Toxic Materials Applicable To Designated Waters	
% of Dissolved Copper Samples Exceeding Copper Standard	84%	100%
Average	0.58	1.551
Median	0.07	0.150
Minimum	0.01	0.020
Maximum	5.04	7.400

Values reported as less than detection limit are not included in average, median, minimum and maximum

As ground and surface waters percolate through rock cracks and fissures within these deposits, some of the exposed sulfide minerals present will preferentially dissolve, resulting in an increase in acidity of the water. With this increase in acidity, additional sulfide minerals are exposed and dissolved. These acidic metal laden waters eventually migrate to Mill Creek. Furthermore, a significant portion of the mining activity at Rio Tinto occurred during a time when mine waste discharge regulations were almost non-existent. It was common practice for mine operators to discharge process residues, tailings and overburden into nearby rivers and creeks. This practice was known to have occurred at the Rio Tinto site, possibly contributing to the Creek's impairment.

Between 1966 and 1975, sludge material from the metals recovery process was routinely discharged into the Rio Tinto tailings impoundment area. This material contained appreciable amounts of iron, cadmium, copper, etc. in the form of metal hydroxides. As acidic mine waters came in contact with the sludge material, the metal hydroxides were re-dissolved and eventually transported to Mill Creek. The presence of copper in the sludge can be attributed to the fact that metal recovery from solution by pH adjustment does not make a fine separation, copper will precipitate out of solution as a copper hydroxide or complex copper-iron hydroxide over a wide pH range between 4.0 and 12.0. Like cadmium, copper often shows an affinity for iron compounds at a pH between 3.0 and 8.0.

3.2.3 Target Analysis: As discussed earlier, NAC 445A.144 sets 200 µg/l as the allowable total recoverable copper concentrations in Mill Creek. Based upon recommendations in *Water Quality Criteria* (National Academy of Sciences, 1972), this standard has been set at a certain level as needed to ensure continued support of the associated beneficial use, being irrigation.

According to the National Academy of Sciences:

> *"Based on toxicity levels in nutrient solutions and limited soils data available, a maximum concentration of 0.20 mg/l copper is recommended for continuous use on all soils."*

Therefore for the purposes of this TMDL, the total copper target has been set at 200 µg/l.

As shown in NAC 445A.144, the acute (1-hour) and chronic (96-hour) dissolved copper standards vary with hardness with the chronic standard being the most restrictive:

$$\text{96-hour dissolved copper standard } (\mu g/l) = 0.85*(2.718^{(0.8545*\ln(H)-1.465)}) \quad \text{(Eq. 4)}$$

Where:

ln = natural logarithm

H = hardness as calcium carbonate (mg/l)

This standard was originally based upon recommendations in *Quality Criteria for Water* (EPA, 1986) for the protection of aquatic life. In developing the recommendations, EPA used the results of numerous acute and chronic toxicity tests for freshwater animals, including fish and macroinvertebrates. Equation 4 incorporates EPA's findings that dissolved copper is more toxic to aquatic life at lower hardness levels. Given that dissolved copper toxicity varies with hardness, one numeric value can not be used for the TMDL target. For that reason, Equation 4 will serve as the dissolved copper target.

3.2.4 Pollutant Load Capacity and Allocation: The total copper Load Capacity or TMDL for Mill Creek (for any given flow) is represented by the following equation:

$$\text{Total copper TMDL (lbs/day)} = \text{Water Quality Target}_{Total} \text{ x Flow x 5.39} \quad \text{(Eq. 5)}$$

$$\text{Dissolved copper TMDL (lbs/day)} = \text{Water Quality Target}_{Dissolved} \text{ x Flow x 5.39} \quad \text{(Eq.6)}$$

Where:

Water Quality Target$_{Total}$ = 0.200 mg/l

Water Quality Target$_{Dissolved}$ $= 0.85*(2.718^{(0.8545*\ln(H)-1.465)})$

Flow = streamflow at water quality monitoring site

5.39 = conversion factor

This TMDL applies to any monitoring site on Mill Creek. While no continuous flow measurements occur on Mill Creek, RTWG has been taking streamflow measurements to coincide with the water quality sampling.

It is recognized that major copper loading is coming from a variety of sources within the Rio Tinto Mine site and downstream areas. Therefore, a gross load allocation that accounts for all these sources has been set and is represented by the following equation:

$$\text{Load Allocation (lbs/day)} = \text{TMDL (lbs/day)} \quad \text{(Eq. 7)}$$

No explicit margin of safety is needed in this equation. As previously discussed, TMDLs are to include a margin of safety to account for uncertainties in meeting the water quality standards when the target and TMDL are met. Through Equations 5 and 6, the TMDL is directly related to the water quality standard with no uncertainty in this relationship. While there is uncertainty in the flow data, this uncertainty impacts both sides of these equations equally.

The TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished through the use of the above equations whereby seasonal affects and critical conditions can be considered.

In some instances, TMDL reports present estimates of load reductions needed for compliance with the load allocations. However, this is not plausible for the Mill Creek TMDL. There are insufficient data to accurately calculate historic loads and associated load reductions. However it can be stated that for TMDL compliance, load reductions are needed such that actual loads are at or below the Load Allocation (from Equation 7) at least 90% of the time[2]. In the absence of flow data, the TMDL is considered to be complied with when the copper levels are below the targets at least 90% of the time.

3.2.5 Future Needs: Following are future needs that have been identified for the phased copper TMDL and related activities:

- The total copper water quality standard for irrigation is over 30 years old and needs to be evaluated. However, Nevada does not have the resources to undertake such a task and in these cases relies upon EPA to provide updated guidance for these standards. Unfortunately, these types of standards are not high on EPA's priority list for revisions.

- Nevada's current standards for dissolved copper are outdated and need to be revised. The new equations developed by EPA (1999) result in 1-hour and 96-hour dissolved copper standard which are approximately 10% lower than the current equations in NAC 445A.144.

3.3 Dissolved Oxygen TMDL

3.3.1 Problem Statement: Table 8 summarizes dissolved oxygen data as collected by NDEP and RTWG and show the frequency of the dissolved oxygen concentration occurring below the water quality standard. Mill Creek was included on the 2002 303(d) List for dissolved oxygen impairment based upon NDEP grab sample data. It must be noted that all NDEP grab sample data were collected during the afternoon hours. Dissolved oxygen concentration fluctuates throughout the day, with minimum values generally occurring near sunrise and maximum values occurring in the afternoon. With this in mind, it is likely that the actual minimum dissolved oxygen levels that occur in the system are lower than the NDEP data would indicate.

Table 8. NDEP and RTWG Dissolved Oxygen Water Quality Standards and Historic Data for Mill Creek (mg/l)

Parameter	Mill Creek - RWTG (SW-2)	Mill Creek - NDEP (E14)
Period of Record	1995-2001	1997-2001
No. of Samples	37	12
NAC 445A.223 Standard	6.00 mg/l	
% of Samples Below Standard	10.53%	25%
Average	9.12	8.42
Median	9.30	7.10
Minimum	2.70	5.31
Maximum	18.10	18.80

3.3.2 Source Analysis: There are several factors which may contribute to lower dissolved oxygen levels in Mill Creek, including algal growth (supported by nutrient loads), decomposition of organic matter in the water column and within the sediments, oxidization of metals from acid mine drainage, temperature, and low streamflow. Insufficient information exists to accurately identify the contribution each may make towards low dissolved oxygen levels. However, it is believed that acid mine drainage from the Rio Tinto Mine is a contributing factor. The existence of "yellowboy" deposits (iron oxide and sulfate deposits from acid mine water). within the stream substrate indicate the occurrence of iron oxidation, which can lower dissolved oxygen levels.

3.3.3 Target Analysis: As discussed earlier, NAC 445A.223 sets 6 mg/l as the minimum dissolved oxygen levels for the East Fork Owyhee River and its tributaries (Mill Creek). Based upon EPA

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[2] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

recommendations, the standard has been set for the protection of a variety of aquatic life during their different life stages. Like terrestrial animals, fish and other aquatic organisms need oxygen to live. With dissolved oxygen levels below the standard, aquatic life production begins to be affected with mortality at the lower levels. Therefore for the purposes of this TMDL, the dissolved oxygen target has been set at 6 mg/l.

3.3.4 Pollutant Load Capacity and Allocation: Unlike most other chemical standards which have a maximum allowable level, dissolved oxygen standards represent a minimum value. Also, while a given chemical impairment is usually due to a loading of that same chemical, a dissolved oxygen impairment is usually due to loadings of other constituents (acid mine drainage, nutrients, organic matter) or other physical factors (streamflow, temperature). With these factors in mind, the dissolved oxygen target can only be met through reduced loads in acid mine drainage, nutrients, organic matter, etc. Currently, there is insufficient information available to determine the maximum allowable loads necessary to meet the dissolved oxygen target. Therefore for the dissolved oxygen TMDL, compliance is assumed to occur when the TMDLs for cadmium, copper, iron and total phosphorus are met, or when the dissolved oxygen target is met at least 90% of the time[3].

3.3.5 Future Needs: Following are future needs that have been identified for the phased dissolved oxygen TMDL and related activities:

- Mill Creek was initially listed for dissolved oxygen impairment based upon grab sample data collected only 3 times a year from 1997 – 2001. Furthermore, all grab sample data collected during this five-year monitoring period were collected during the afternoon hours. Although dissolved oxygen concentrations fluctuate throughout the day, minimum values generally occurring near sunrise and maximum values occurring in the afternoon. With this in mind, the possibility exists that the few historic grab samples collected only captured the extreme daily highs rather than the critical daily lows. It is recommended that additional monitoring (with continuous dissolved oxygen monitors) be undertaken to confirm violations of the dissolved oxygen standard.

- As a single value standard, the current dissolved oxygen standard stated in NAC 445A.222 and NAC445A.223 is outdated. Current EPA guidance suggests dissolved oxygen criteria much more involved, including thresholds for 1-day minimums, 7-day mean minimums, 7-day means and 30-day means. NDEP intends to consider revision of the existing regulations into a format similar to the current EPA guidance, which includes duration needs.

- The impacts of past and current activities at the Rio Tinto mine site on dissolved oxygen impairment in Mill Creek are not easily understood, due to the complex chemical and physical relationships that exist. Improved understanding of the relationships between dissolved oxygen, acid mine drainage, and the nutrients is needed.

3.4 Iron (Total)

3.4.1 Problem Statement and Source Analysis: Tables 9 and 10 summarize total iron data as collected by NDEP and RTWG and show frequency of exceedence of the water quality standard. By far the highest iron levels are occurring in Mill Creek. The data show that exceedences of the total recoverable iron beneficial use standard occur throughout the year. Significant exceedences often occur during the spring run-off period and late summer. Included in the data for Station E4 (East Fork Owyhee River

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[3] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

above Mill Creek) is an abnormally high iron concentration of 23.40 mg/l (March 24, 1998). With the next highest E4 concentration at 1.33 mg/l, the 23.40 value needs to be considered suspect.
Based upon NDEP's data for 1997-2001, Mill Creek and the East Fork Owyhee River (above Mill Creek) were included on the 2002 303(d) List for total iron. The lower reach of the East Fork Owyhee River (below Mill Creek) was not included on the List due to the lack of sufficient data.[4] It is expected that the lower reach will need to be listed for iron as additional data are collected.

Table 9. NDEP Total Iron Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (mg/l)

Parameter	Below Wild Horse Reservoir (E12)	Above Mill Creek (E4)	Mill Creek (E14)	Below Mill Creek (E15)	Below Slaughter house Creek (E16)	Below China Diversion (E3)
Period of Record	1996-2001	1989-2001	1997-2001	2000-2001	2000-2001	1989-99 Discontinued
No. of Samples	15	27	12	6	6	21
NAC Standard	NAC 445A.144 Standards For Toxic Materials Applicable To Designated Waters Total Recoverable Iron Aquatic Life Standard: 1.0 mg/l					
% Samples Exceeding Standard	7%	19%	100%	50%	17%	16%
Average	0.67	1.45	22.01	0.85	0.90	0.70
Median	0.46	0.45	8.33	0.37	0.42	0.52
Minimum	0.26	0.16	1.56	0.06	0.17	0.19
Maximum	3.19	23.40	74.20	2.28	2.09	2.22

Table 10. RTWG Total Iron Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (mg/l)

Parameter	Above Mill Creek (SW-3)	Mill Creek (SW-2)	Below Mill Creek (SW-4)
Period of Record	1995-2001	1995-2001	1995-2001
Number of Samples	35	32	34
NAC Standard 1.0 mg/l	**NAC 445A.144 "Standards For Toxic Materials Applicable To Designated Waters"**		
% Samples Exceeding Standard	22%	94%	44%
Average	0.79	16.37	1.88
Median	0.51	10.55	0.84
Minimum	0.18	0.12	0.03
Maximum	3.46	70.80	18.00

3.4.2 Source Analysis: Natural and man-caused activities have contributed to the iron impairment of Mill Creek and the East Fork Owyhee River. Iron is a fairly common rock and soil constituent found in Nevada and it is not uncommon for waterbodies throughout the state to exhibit high concentrations of

[4] As described in Nevada's 2002 303(d) List, in general a minimum of 10 samples collected during 1997-2001 were needed for a dataset to be considered in the 303(d) analysis.

iron, primarily the result of natural run-off and seepage. However, Rio Tinto's contribution is considered to be the major source in the Mill Creek drainage.

Impoundment pond overflow, tailings runoff, natural seepage from iron-bearing waste rock, and acidic mine waters at the Rio Tinto Mine site have also contributed to the Creek and River's iron impairment. As ground and surface waters percolate through rock cracks and fissures within these deposits, some of the exposed sulfide minerals present will preferentially dissolve, resulting in an increase in acidity of the water. With this increase in acidity, additional sulfide minerals are exposed and dissolved. These acidic metal laden waters eventually migrate to Mill Creek. Furthermore, a significant portion of the mining activity at Rio Tinto occurred during a time when mine waste discharge regulations were almost non-existent. It was common practice for mine operators to discharge process residues, tailings and overburden into nearby rivers and creeks. This practice was known to have occurred at the Rio Tinto site, possibly contributing to the Creek's impairment.

Between 1966 and 1975, sludge material from the metals recovery process was routinely discharged into the Rio Tinto tailings impoundment area. This material contained appreciable amounts of iron, cadmium, copper, etc. in the form of metal hydroxides. As acidic mine waters came in contact with the sludge material, the metal hydroxides were re-dissolved and eventually transported to Mill Creek. The presence of iron in the sludge can be attributed to the fact that when metals are recovered from solution by pH adjustment, iron is the first metal to precipitate out of solution as iron hydroxide at a pH range between 2.3 and 3.5.

3.4.3 Target Analysis: As discussed earlier, NAC 445A.144 sets 1,000 µg/l as the allowable total recoverable iron concentrations in Mill Creek and East Fork Owyhee River. This standard has been set at a certain level as needed to ensure continued support of the associated beneficial use, being aquatic life.

Nevada's iron standard was taken from EPA's 1976 publication – "Quality Criteria for Water", also referred to as the Red Book. According to the Red Book, the main problems associated with elevated iron levels include toxicity to fish and macroinvertebrates; and iron precipitates covering stream bottoms thereby destroying bottom-dwelling invertebrates, plants or incubating fish eggs. For the purposes of this TMDL, the total iron target has been set at the iron water quality standard of 1,000 µg/l for the 3 reaches in question: 1) EF Owyhee River above Mill Creek; 2) EF Owyhee River below Mill Creek; and 3) Mill Creek.

3.4.4 Pollutant Load Capacity and Allocation: The total iron Load Capacity or TMDL for Mill Creek and East Fork Owyhee River (for any given flow) is represented by the following equation:

Total iron TMDL (lbs/day) = Water Quality Target x Flow x 5.39 (Eq. 8)

Where:

Water Quality Target = 1 mg/l
Flow = streamflow at water quality monitoring site and USGS gaging stations[5]
5.39 = conversion factor

It is recognized that the major iron loading is coming from within the Rio Tinto Mine area and other

[5] For NAC 445A.222: East Fork Owyhee River – Wildhorse Reservoir to Mill Creek, no USGS gaging station exists at the lower end of this reach. For Mill Creek – no USGS gaging station exists. Use of this equation for these two reaches would require concurrent flow measurements taken at the time of water quality sampling. For NAC 445A.223: East Fork Owyhee River – Mill Creek to Duck Valley Indian Reservation, USGS Station 13175100) provides streamflow data for use in this equation.

sources in the watershed. Therefore, a gross load allocation that accounts for all these sources has been set and is represented by the following equation:

$$\textit{Load Allocation (lbs/day)} = \textit{TMDL (lbs/day)} \qquad \textit{(Eq. 9)}$$

No explicit margin of safety is needed in this equation. As previously discussed, TMDLs are to include a margin of safety to account for uncertainties in meeting the water quality standards when the target and TMDL are met. Through Equation 8, the TMDL is directly related to the water quality standard with no uncertainty in this relationship. While there is uncertainty in the flow data, this uncertainty impacts both sides of Equation 8 equally.

The TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished through the use of the above equations whereby seasonal affects and critical conditions can be considered.

In some instances, TMDL reports present estimates of load reductions needed for compliance with the load allocations. However, this is not plausible for the East Fork Owyhee River and Mill Creek TMDL. There are insufficient data to accurately calculate historic loads and associated load reductions. However it can be stated that for TMDL compliance, load reductions are needed such that actual loads are at or below the Load Allocation (from Equation 9) at least 90% of the time[6]. In the absence of flow data, the TMDL is considered to be complied with when the total iron levels are below the target (1 mg/l) at least 90% of the time.

3.4.5 Future Needs: Following are future needs identified for the phased iron TMDL and related activities

- As stated earlier, Mill Creek and EF Owyhee iron loadings can be attributed to human-caused sources and natural sources within the watershed. It has been suggested that additional work is needed to better identify and quantify these various iron sources, differentiating between natural and human-caused sources.

- Before significant resources are spent on better characterizing iron sources, revision of the iron standard should be considered. As discussed above, Nevada's total iron water quality criteria was taken from EPA's Red Book. Upon closer examination, it becomes obvious that the Red Book criteria of 1.0 mg/l was based upon minimal information and its appropriateness needs to be questioned. In more recent years, EPA has been following a rather rigorous analysis in setting criteria for toxics. This same approach needs to be taken in revising the iron criteria. Other states are also recognizing the need for more appropriate iron criteria. In fact, Ohio EPA recently deleted their iron aquatic life standard of 1 mg/l. Based upon the presence of healthy aquatic populations in waters exceeding the 1 mg/l level, Ohio EPA concluded that this standard was not appropriate (Vorys, Sater, Seymour and Pease LLP, 2003).

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[6] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

3.5 pH TMDL

Table 11. NDEP and RTWG pH Water Quality Standards and Historic Data for Mill Creek

Parameter	Mill Creek (SW-2)	Mill Creek (E14)
Period of Record	1995-2001	1997-2001
No. of Samples	32	14
NAC Standards	NAC 445A .223 pH between 6.5 and 9.0	
% of Samples Deviating From Standards	59%	67%
Average	6.06	5.69
Median	6.35	6.79
Minimum	3.4	2.96
Maximum	8.0	8.28

3.5.1 Problem Statement: Table 11 summarizes pH data collected by NDEP and RTWG and shows frequency of exceedances of the water quality standard for Mill Creek. A majority of the pH exceedances occurred in the late summer and fall during low flow periods.

Based upon NDEP's data, Mill Creek was included on the 2002 303(d) List. None of the East Fork Owyhee River data compiled indicated sufficient pH standard exceedances to justify 303(d) Listing.

3.5.2 Source Analysis: The Rio Tinto mine has long been identified as a significant contributor to the pH impairment of Mill Creek. As stated earlier, significant concentrations of sulfide minerals are found throughout the Mountain City-Pattsville-Owyhee area, in addition to the Rio Tinto site. The presence of these minerals in the presence of sufficient water and oxygen has a significant affect on pH and the generation of acid mine waters.

The percolation of neutral or slightly acidic ground and surface waters through rock cracks, fissures and voids, preferentially dissolves the sulfide minerals present. As these minerals dissolve (solubilize), the waters become more acidic, thus creating conditions favorable for additional minerals to solubilize and the waters to become even more acidic until equilibrium is finally reached. Under the most favorable of conditions, a metal sulfide combined with sufficient amounts of dissolved oxygen and water will generate dissolved metal, sulfate and hydrogen species. Consequently, as the chemical reaction proceeds, the dissolved hydrogen concentration in solution increases (i.e. pH decreases) and will continue to solubilize metal sulfides and metals present and further increase the total dissolved solids concentration. Note that the generation of acid mine waters is extremely complex and is dependent on a variety of natural factors such as precipitation, run-off, temperature, surface flow and groundwater flow. In addition, chemical and physical factors such as pH, minerals/metals present, oxygen availability, bacteria present, surface chemistry and geological setting impact and contribute to the generation of acid mine waters.

3.5.3 Target Analysis: As discussed earlier, NAC 445A sets 6.5 to 9 as the allowable pH range for the East Fork Owyhee River and its tributaries (Mill Creek). Based upon EPA recommendations (EPA, 1986), the standard has been set for the protection of a variety of aquatic life forms during their different life stages. Research has shown that pH levels outside this range can impact vital life functions. Therefore for the purposes of this TMDL, the pH target has been set at 6.5 to 9 for Mill Creek.

3.5.4 Pollutant Load Capacity and Allocation: Unlike most other chemical standards which have a maximum allowable level, pH standards represent both a minimum and maximum value. Also, pH standards are not in concentration units (mg/l) complicating load capacity determination. 40 CFR § 130.2(i) provides flexibility in how TMDLs can be presented and suggests that they may be expressed in terms of "mass per time, toxicity, or other appropriate measure." For this pH TMDL, it has been determined that the appropriate measure for the allocation should be in terms of pH units. Therefore, the gross load allocation requires that the pH of water within Mill Creek shall be no less than 6.5 and no more than 9.0, under all flow regimes (except for extreme low flow periods as provided in NAC 445A.121(8)).

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No explicit margin of safety is needed for this load allocation as it is directly related to the water quality standard/target. Also, the TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished by requiring compliance with the pH standard/target under all flow regimes. In general, the TMDL is considered to be complied with when the Mill Creek pH levels are between 6.5 and 9.0 at least 90% of the time[7].

3.5.5 Future Needs: Following are future needs identified for the phased pH TMDL and related activities:

- It may be that the remediation activities needed to comply with the metals TMDLs (cadmium, copper and iron) will also result in compliance with the pH standard. Additional work is needed to better under this relationship for subsequent phases of this TMDL.

3.6 Phosphorus (Total) TMDL

3.6.1 Problem Statement: Tables 12 and 13 summarize total phosphorus data as collected by NDEP and RTWG and show frequency of exceedence of the water quality standard. Based upon NDEP's data for 1997-2001, Mill Creek and the East Fork Owyhee River were included on the 2002 303(d) List. The data show that the phosphorus standard is frequently exceeded throughout the East Fork Owyhee River and Mill Creek system with exceedances often occurring during the spring and summer months, however significant exceedences have also been documented during the winter months.

Table 12. NDEP Total Phosphorus Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (mg/l)

Parameter	Below Wild Horse Reservoir (E12)	Above Mill Creek (E4)	Mill Creek (E14)	Below Mill Creek (E15)	Below Slaughter house Creek (E16)	Below China Diversion (E3)
Period of Record	1996-2001	1989-2001	1997-2001	2000-2001	2000-2001	1989-99 Discontinued
No. of Samples	15	27	13	6	6	21
NAC Standard	NAC 445A .222 0.10 mg/L		NAC 445A .223 0.10 mg/L			
% Samples Exceeding Standard	69%	56%	23%	33%	33%	38%
Average	0.12	0.13	0.10	0.08	0.09	0.11
Median	0.11	0.10	0.07	0.08	0.08	0.10
Minimum	0.02	0.02	0.02	0.05	0.05	0.03
Maximum	0.28	0.43	0.33	0.12	0.14	0.21

[7] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

Table 13. RTWG Total Phosphorus Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (mg/l)

Parameter	Above Mill Creek (SW-3)	Mill Creek (SW-2)	Below Mill Creek (SW-4)
Period of Record	1995-2001	1995-2001	1995-2001
Number of Samples	34	31	32
NAC Standard	NAC 445A .222 0.10 mg/L	NAC 445A .223 0.10 mg/L	
% Samples Exceeding Standard	17%	16%	21%
Average	0.06	0.05	0.06
Median	0.06	0.03	0.07
Minimum	0.01	0.01	0.01
Maximum	0.23	0.15	0.23

3.6.2 Source Analysis: The phosphorus sources within the EF Owyhee River and Mill Creek watersheds are believed to be varied and largely due to the naturally high phosphorus levels in Nevada soils. Phosphorus loads may be originating from watershed and streambank erosion, occurring naturally and/or as the result of land use practices (irrigation, grazing, recreation, mining). However, identifying the exact sources and pathways of phosphorus impairment for the Creek and River is difficult at this time due to lack of detailed data.

3.6.3 Target Analysis: As discussed earlier, NAC 445A sets 0.1 mg/l as the allowable total phosphorus concentrations in the East Fork Owyhee River and Mill Creek. This standard has been set at a certain level as needed to ensure continued support of the associated beneficial use, being aquatic live. Based upon EPA recommendations (1986), the total phosphorus standard was set to control eutrophication in streams and lakes. Algal growths impart undesirable tastes and odors, interfere with recreational values and alter the chemistry of the water, including dissolved oxygen levels. Therefore for purposes of this TMDL, the total phosphorus target has been set at 0.1 mg/l for the 3 reaches in question: 1) EF Owyhee River above Mill Creek; 2) EF Owyhee River below Mill Creek; and 3) Mill Creek.

3.6.4 Pollutant Load Capacity and Allocation: The total phosphorus Load Capacity or TMDL for Mill Creek and East Fork Owyhee River (for any given flow) is represented by the following equation:

Total phosphorus TMDL (lbs/day) = Water Quality Target x Flow x 5.39 (Eq. 10)

Where:

Water Quality Target = 0.1 mg/l
Flow = streamflow at water quality monitoring site and USGS gaging stations[8]
5.39 = conversion factor

[8] For NAC 445A.222: East Fork Owyhee River – Wildhorse Reservoir to Mill Creek, no USGS gaging station exists at the lower end of this reach. For Mill Creek – no USGS gaging station exists. Use of this equation for these two reaches would require concurrent flow measurements taken at the time of water quality sampling. For NAC 445A.223: East Fork Owyhee River – Mill Creek to Duck Valley Indian Reservation, USGS Station 13175100) provides streamflow data for use in this equation.

It is recognized that the phosphorus loading is coming from nonpoint sources throughout the watershed. Therefore, a gross load allocation that accounts for all these sources has been set and is represented by the following equation:

$$\textit{Load Allocation (lbs/day)} = \textit{TMDL (lbs/day)} \qquad \textit{(Eq. 11)}$$

No explicit margin of safety is needed in this equation. As previously discussed, TMDLs are to include a margin of safety to account for uncertainties in meeting the water quality standards when the target and TMDL are met. Through Equation 10, the TMDL is directly related to the water quality standard with no uncertainty in this relationship. While there is uncertainty in the flow data, this uncertainty impacts both sides of Equation 10 equally.

The TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished through the use of the above equations whereby seasonal affects and critical conditions can be considered.

In some instances, TMDL reports present estimates of load reductions needed for compliance with the load allocations. However, this is not plausible for the East Fork Owyhee River and Mill Creek TMDL. There are insufficient data to accurately calculate historic loads and associated load reductions. However it can be stated that for TMDL compliance, load reductions are needed such that actual loads are at or below the Load Allocation (from Equation 11) at least 90% of the time[9]. In the absence of flow data, the TMDL is considered to be complied with when the total iron levels are below the target (1 mg/l) at least 90% of the time.

3.6.5 Future Needs: Following are future needs that have been identified for the phased phosphorus TMDL and related activities:

- Little is known about the specific phosphorus sources within the watershed. As stated earlier, potential phosphorus sources include natural erosion in the watershed and the stream channel, and other land use practices. A source assessment may be needed to characterize (location, amount, timing) the various sources within the watershed.

- Before a large amount of resources are devoted to developing more complex TMDLs and control strategies, it is advisable to evaluate the suitability of the existing water quality standards for total phosphorus and other nutrients. The standard of 0.1 mg/l annual average applies across much of the state and is based on recommendations made in the Gold Book. These recommendations are not strongly supported in the Gold Book and are not identified as criteria, but rather as a “desired goal for the prevention of plant nuisances”. Given the native soil conditions in the Great Basin and the topography that exists over much of Nevada, the suitability of the total phosphorus water quality standard must be questioned. It is clear that additional research is needed on the role of total phosphorus in eutrophication. Studies performed on the Truckee River and Pyramid Lake show that, in fact, nitrogen rather than phosphorus is the limiting nutrient.

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[9] As described in Nevada’s 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

3.7 Temperature

3.7.1 Problem Statement: Tables 14 and 15 summarize temperature data as collected by NDEP and RTWG and show frequency of exceedance of the seasonal temperature standards. Evaluation of NDEP and RTWG data, shows exceedances of the seasonal temperature standards occurring throughout the year and throughout the entire flow range. Based upon the NDEP data, Mill Creek and East Fork Owyhee River (above Mill Creek) were included on the 2002 303(d) List for temperature. There was insufficient data to include the "EF Owyhee River below Mill Creek " reach on the 2002 303(d) List due to the lack of data[10].

3.7.2 Source Analysis: Some key factors potentially affecting water temperatures in Mill Creek and EF Owyhee River include riparian vegetation, stream flow, climate. While climate is outside the sphere of human control, riparian conditions and streamflow can be affected by land use activities.

Additionally, a secondary contributor to temperature impairment could be the processes that generate acid mine waters. When sufficient water, oxygen and sulfide/metal tolerant bacteria (i.e. *Thiobacillius ferrooxidans, T. novellas* and *T. thioporus*) are available, sulfide minerals will preferentially oxidize and solubilize (dissolve), liberating heat (i.e. an exothermic reaction) and lowering pH in the process. This liberation of heat often results in localized water temperature increases (i.e. pockets). A rise in temperature by just a few degrees will significantly increase the rate of the oxidation and dissolution reactions, consequently decreasing pH even further (i.e. become more acidic), which in turn will dissolve those sulfides/metals which would not dissolve under slightly acidic conditions, generating even more heat and a temperature increase.

3.7.3 Target Analysis: As discussed earlier, NAC 445A sets the allowable water temperatures in the East Fork Owyhee River and Mill Creek. Based upon recommendations from the Nevada Department of Wildlife, these standards were set at levels needed to ensure continued support of the associated beneficial use, being aquatic life. The ultimate goal of this TMDL is to support these uses through compliance with the temperature standards shown below:

Temperature target (May – October) - $<21^{o}$ C
Temperature target (November – April) - $<7^{o}$ C

3.7.4 Pollutant Load Capacity and Allocation: 40 CFR § 130.2(i) provides flexibility in how TMDLs can be presented and suggests that they may be expressed in terms of "mass per time, toxicity, or other appropriate measure." For this temperature TMDL, it has been determined that the appropriate measure for the allocation should be in terms of degrees Celsius. While many temperature TMDLs throughout the country report the load allocations in terms of heat loading (calories per day, etc.), there is insufficient information to use this approach for Mill Creek and the EF Owyhee River. Therefore, the load allocation requires that the temperature of water within Mill Creek and the EF Owyhee River shall be no more than the temperature targets/standards, under all flow regimes (except for extreme low flow periods as provided in NAC 445A.121(8)).

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[10] As described in Nevada's 2002 303(d) List, in general a minimum of 10 samples collected during 1997-2001 were needed for a dataset to be considered in the 303(d) analysis.

Table 14. NDEP Temperature Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (^oC)

Parameter	Below Wild Horse Reservoir (E12)	Above Mill Creek (E4)	Mill Creek (E14)	Below Mill Creek (E15)	Below Slaughter house Creek(E16)	Below China Diversion (E3)
Period of Record	19967-2001	1979-2001	1997-2001	2000-2001	2000-2001	1989-99
NAC Standard	NAC 445A .222 May – October (<21^o C)		NAC 445A .223 May – October (<21^o C)			
Number of Samples	11	20	8	4	4	15
% of Samples Exceeding Standard	0%	14%	63%	25%	50%	40%
Average	15.2	16.0	21.7	18.8	19.6	17.8
Median	15.7	17.8	21.5	18.6	19.5	18.0
Minimum	10.0	5.0	15.9	17.0	18.0	8.3
Maximum	17.7	25.0	31.0	21.0	21.5	25.3
NAC Standard	NAC 445A .222 November – April (<7^o C)		NAC 445A .223 November - April (<7^o C)			
Number of Samples	4	4	4	2	2	5
% of Samples Exceeding Standard	0%	75%	25%	50%	0%	0%
Average	4.7	7.6	5.1	5.7	5.3	5.0
Median	4.6	7.3	5.0	5.7	5.3	4.8
Minimum	3.5	5.1	3.4	4.1	4.0	4.1
Maximum	6.0	10.5	7.0	7.2	6.5	6.5

Table 15. RTWG Temperature Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (^oC)

Parameter	Above Mill Creek (SW-3)	Mill Creek (SW-2)	Below Mill Creek (SW-4)
Period of Record	1995-2001	1995-2001	1995-2001
NAC Standard	NAC 445A .222 May – October (<21^o C)	NAC 445A .223 May – October (<21^o C)	
Number of Samples	18	18	18
% of Samples Exceeding Standard	16%	22%	22%
Average	14.17	14.82	14.99
Median	13.40	14.55	14.70
Minimum	6.40	2.30	3.40
Maximum	24.90	25.70	24.90
NAC Standard	NAC 445A .222 November – April (<7^o C)	NAC 445A .223 November - April (<7^o C)	
Number of Samples	16	15	16
% of Samples Exceeding Standard	19%	7%	19%
Average	4.72	2.74	3.90
Median	4.85	1.50	3.65
Minimum	0.10	0.00	0.10
Maximum	14.30	7.30	12.10

No explicit margin of safety is needed for this load allocation as it is expressed as the water quality standard/target. Also, the TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished by requiring compliance with the temperature standard/target under all flow regimes. In general, the TMDL is considered to be complied with when the Mill Creek and EF Owyhee River temperature levels are below the targets at least 90% of the time[11].

3.7.5 Future Needs: Following are future needs that have been identified for the phased temperature TMDL and related activities:

- Mill Creek and the East Fork Owyhee River were listed for temperature impairment based on limited grab sample collected only 3 times a year in the afternoons during the 1997 – 2001 monitoring period. More detailed monitoring is needed to better characterize the extent of the high temperatures and their frequency.

- As stated earlier, many factors could be contributing to temperature impairment in Mill Creek and the East Fork Owyhee River. Because of the complex chemical-geological-biological relationships that exist, identifying actual sources and pathways of the impairment are difficult at this time. Future efforts are needed to improve understanding of the temperature relationships and heat loadings within the watershed.

- Additionally, statewide temperature standards need to be reviewed. Current temperature standards are "single value" standards, without any consideration of duration. A more appropriate temperature standard would include thresholds for 7-day means, 7-day mean maximums, etc.

3.8 Total Suspended Solids and Turbidity

3.8.1 Problem Statement: Tables 16 through 19 summarize total suspended solids (TSS) and turbidity data as collected by NDEP and RTWG and show frequency of exceedence of the water quality standards. Exceedances of the TSS and turbidity standards occur throughout the study area, with the most frequent exceedances occurring in Mill Creek. The springtime is the most common period for elevated TSS and turbidity levels. Based upon NDEP's data, Mill Creek and the East Fork Owyhee River (from Wildhorse Reservoir to Duck Valley Indian Reservation) were included on the 2002 303(d) List for TSS and turbidity.

3.8.2 Source Analysis: Numerous potential sediment sources exist within the Mill Creek/EF Owyhee River watershed such as natural erosion in the watershed and the stream channel, and erosion from dirt roads, trails, mining activities, grazing, etc. The impact of the Rio Tinto remediation activities on sediment loading is unknown at this time.

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[11] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

Table 16. NDEP Total Suspended Solids Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (mg/l)

Parameter	Below Wild Horse Reservoir (E12)	Above Mill Creek (E4)	Mill Creek (E14)	Below Mill Creek (E15)	Below Slaughter house Creek (E16)	Below China Diversion (E3)
Period of Record	1996-2001	1979-2001	1997-2001	2000-Present	2000-Present	1989-99 Discontinued
No. of Samples	16	25	12	6	6	21
NAC Standard	NAC 445A .222 25.0 mg/L		NAC 445A .223 25.0 mg/L			
% Samples Exceeding Standard	13%	32%	75%	50%	33%	29%
Average	11.53	32.84	62.15	12.33	16.67	26.90
Median	6.00	15.00	62.00	8.50	7.80	12.50
Minimum	3.00	3.00	10.00	4.00	5.00	2.00
Maximum	54.00	332.00	202.00	30.00	47.00	178.00

Table 17. RTWG Total Suspended Solids Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (mg/l)

Parameter	Above Mill Creek (SW-3)	Mill Creek (SW-2)	Below Mill Creek (SW-4)
Period of Record	1995-2001	1995-2001	1995-2001
Number of Samples	34	32	26
NAC Standard 25.0 mg/L	NAC 445A .222	NAC 445A .223	
% Samples Exceeding Standard	17%	60%	35%
Average	14.09	43.38	22.35
Median	7.00	43.00	14.50
Minimum	5.00	5.00	6.00
Maximum	62.00	186.00	72.00

3.8.3 Target Analysis : As discussed earlier, NAC 445A.222 and 445A.223 set 10 NTU and 25 mg/l as the water quality standards for turbidity and total suspended solids, respectively. Nevada's turbidity and TSS standards were taken from past water quality criteria publication (National Technical Advisory Committee, 1968; National Academy of Sciences, 1972). These standards have been set at a certain level as needed to ensure continued support of the associated beneficial use, being aquatic life. Turbidity and TSS can impact aquatic life in several ways: 1) settleable solids block stream bottoms gravels affecting macroinvertebrate and fish egg survival; 2) sediment can clog gills interfering with respiration; 3) sediment can be abrasive to gills; and 4) sediment can impair the ability of sight-feeding species (such as trout) to feed.

Table 18. NDEP Turbidity Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (NTU)

Parameter	Below Wild Horse Reservoir (E12)	Above Mill Creek (E4)	Mill Creek (E14)	Below Mill Creek (E15)	Below Slaughter house Creek (E16)	Below China Diversion (E3)
Period of Record	1996-2001	1979-2001	1997-2001	2000-Present	2000-Present	1989-99 Discontinued
No. of Samples	15	25	11	6	6	19
NAC Standard 10.0 NTU	NAC 445A .222		NAC 445A .223			
% Samples Exceeding Standard	7%	44%	100%	33%	33%	42%
Average	8.75	19.9	107.9	9.53	10.2	16.8
Median	6.3	9.4	60	6.1	6.4	9.9
Minimum	3.7	3.2	18.9	3.2	1.7	2.6
Maximum	35	227	387	21	26	123

Table 19. RTWG Turbidity Water Quality Standards and Historic Data for East Fork Owyhee River and Mill Creek (NTU)

Parameter	Above Mill Creek (SW-3)	Mill Creek (SW-2)	Below Mill Creek (SW-4)
Period of Record	1995-2001	1995-2001	1995-2001
Number of Samples	34	32	34
NAC Standard 10.0 NTU	NAC 445A .222	NAC 445A .223	
% Samples Exceeding Standard	22%	91%	42%
Average	9.18	65.41	16.59
Median	5.10	40.35	8.45
Minimum	1.30	0.30	2.00
Maximum	49.20	300.00	139.00

The turbidity standard of measurement (NTU) is unique in the fact that it is not directly amenable to any loading equation. Therefore, the use of TSS as a surrogate for turbidity was evaluated. Using a linear regression approach, relationships between turbidity and TSS were developed for the various monitoring stations at the lower limits of the 3 reaches in question: 1) EF Owyhee River above Mill Creek; 2) EF Owyhee River below Mill Creek; and 3) Mill Creek. Of the data examined, only NDEP Station E4 (EF Owyhee River above Mill Creek) data yielded a useful regression equation (correlation coefficient, R^2 = 0.98):

$$TSS\ (mg/l) = Turbidity\ (NTU) \times 1.498 \quad (Eq.\ 12)$$

For the other stations, the correlation coefficients (R^2) indicated poor relationships or there were not sufficient samples to develop an appropriate relationship. Based upon Equation 12, a turbidity level of 10 NTU at E4 (EF Owyhee River above Mill Creek) equates to a TSS level of 15 mg/l at E4. Therefore, a TSS level of 15 mg/l is needed to meet the turbidity standard and has been selected as the target for the East Fork Owyhee River (above Mill Creek). For the other reaches, both turbidity and TSS targets are needed (Table 20).

Table 20. Turbidity and Total Suspended Solids Targets for East Fork Owyhee River and Mill Creek

Reach Identification	Turbidity Target	TSS Targets
EF Owyhee River – Wildhorse Reservoir to Mill Creek	TSS target of 15 mg/l needed to meet both the turbidity and the TSS standards	
EF Owyhee River – Mill Creek to Duck Valley Reservation Boundary	10 NTU	25 mg/l
Mill Creek	10 NTU	25 mg/l

3.8.4 Pollutant Load Capacity and Allocation: The TSS Load Capacities or TMDLs for Mill Creek and EF Owyhee River (for any given flow) are represented by the following equation:

TSS TMDL (lbs/day) = Water Quality Target x Flow x 5.39   (Eq. 13)

Where:

Water Quality Target:

EF Owyhee River – Wildhorse Reservoir to Mill Creek = 14 mg/l
EF Owyhee River – Mill Creek to Duck Valley Indian Reservation = 25 mg/l
Mill Creek = 25 mg/l

Flow = streamflow at monitoring sites or USGS gaging station[12]
5.39 = conversion factor

This TMDL applies to both the NDEP and RTWG monitoring sites. While no continuous flow measurements occur on Mill Creek, RTWG has been taking streamflow measurements to coincide with the water quality sampling.

It is recognized that major TSS loading is coming from a variety of nonpoint sources within the watersheds. Therefore, a gross load allocation that accounts for all these sources has been set and is represented by the following equation:

Load Allocation (lbs/day) = TMDL (lbs/day) x Margin of Safety   (Eq. 14)

Where:

Margin of Safety:

EF Owyhee River – Wildhorse Reservoir to Mill Creek = 0.90
EF Owyhee River – Mill Creek to Duck Valley Indian Reservation = 1.0
Mill Creek = 1.0

[12] For NAC 445A.222: East Fork Owyhee River – Wildhorse Reservoir to Mill Creek, no USGS gaging station exists at the lower end of this reach. For Mill Creek – no USGS gaging station exists. Use of this equation for these two reaches would require concurrent flow measurements taken at the time of water quality sampling. For NAC 445A.223: East Fork Owyhee River – Mill Creek to Duck Valley Indian Reservation, USGS Station 13175100) provides streamflow data for use in this equation.

As previously discussed, TMDLs are to include a margin of safety to account for uncertainties in meeting the water quality standards when the target and TMDL are met. A factor of 0.90 has been selected for EF Owyhee River (above Mill Creek) to account for uncertainty in the relationship between TSS and turbidity. No explicit margin of safety is needed for the other reaches. Through Equation 13, the TMDL is directly related to the water quality standard with no uncertainty in this relationship. While there is uncertainty in the gaging station flow data, this uncertainty impacts both sides of Equation 13 equally.

The TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished through the use of the above equations whereby seasonal effects and critical conditions can be considered.

In some instances, TMDL reports present estimates of load reductions needed for compliance with the load allocations. However, this is not plausible for the Mill Creek and EF Owyhee River TSS TMDLs. There are insufficient data to accurately calculate historic loads and associated load reductions. However it can be stated that for TMDL compliance, load reductions are needed such that actual loads are at or below the Load Allocation (from Equation 14) at least 90% of the time[13]. In the absence of flow data, the TMDL is considered to be complied with when the TSS levels are below the targets (Table 20) at least 90% of the time.

As already presented, the turbidity target for the lower EF Owyhee River and Mill Creek can not be represented as a load. 40 CFR § 130.2(i) provides flexibility in how TMDLs can be presented and suggests that they may be expressed in terms of "mass per time, toxicity, or other appropriate measure." For the turbidity TMDL (for Mill Creek and EF Owyhee River below Mill Creek), it has been determined that the appropriate measure for the allocation should be in terms of turbidity units (NTUs). Therefore, the load allocation requires that the turbidity of water within Mill Creek and the EF Owyhee River (below Mill Creek) shall be no more than 10 NTUs under all flow regimes (except for extreme high flow periods as provided in NAC 445A.121(8)). For turbidity, the TMDL is considered to be complied with when the turbidity levels are below the targets (Table 20) at least 90% of the time.

3.8.5 Future Needs: Following are future needs identified for the phased TSS/turbidity TMDL and related activities:

- Little is known about the specific TSS and turbidity sources within the watershed. As stated earlier, potential sediment sources in the watershed include natural erosion in the watershed and the stream channel, and erosion from dirt roads, trails, mining activities, grazing, etc. Additional work is needed to characterize (location, amount, timing) the various sources within the watershed, and separate out natural and human-caused sources.

- As additional data are collected, the linear regression relationships between TSS and turbidity can be revisited for subsequent TMDL revisions.

- The TSS and turbidity standards for waters throughout the state are based upon outdated national guidance and may not be appropriate for all waters. The shortcomings of sediment-related criteria throughout the nation has been recognized and EPA is developing a strategy for improved criteria (2003).

[13] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

3.9 Total Dissolved Solids

3.9.1 Problem Statement: Table 21 summarizes total dissolved solids (TDS) data as collected by NDEP and RTWG and show the frequency of the exceedence of the water quality standard. A majority of the elevated TDS concentrations occurred during low flow periods. Based upon NDEP data, Mill Creek was included on the 2002 303(d) List for TDS. The data did not indicate any TDS standard exceedances for the East Fork Owyhee River.

3.9.2 Source Analysis: Discharges from the Rio Tinto Mine area are believed to be the main contributor to the elevated TDS concentrations in Mill Creek. Data presented by RTWG (November 2002) indicate that Mill Creek TDS levels upstream of Rio Tinto are typically in the 50 to 200 mg/l range, well within the water quality standard of 500 mg/l.

Table 21. NDEP Total Dissolved Solids Water Quality Standards and Historic Data for Mill Creek (mg/l)

Parameter	Mill Creek (SW-2)	Mill Creek (E14)
Period of Record	1995-2001	1997-2001
No. of Samples (Total Dissolved Solids)	33	13
NAC Standard	NAC 445A .223 500 mg/l	
% of Samples Exceeding Standard	27%	46%
Average	455.31	544.23
Median	287.50	388
Minimum	80.00	99
Maximum	3,700	1231

3.9.3 Target Analysis As discussed earlier, NAC 445A sets 500 mg/l as the allowable TDS concentration in Mill Creek. This standard has been set at a certain level as needed to ensure continued support of the associated beneficial use, being municipal or domestic water supply. While Mill Creek is not currently used as a drinking water source, "municipal or domestic water supply" has been identified as one of its designated or potential beneficial uses. As such, these criteria still apply.

The TDS standard of 500 mg/l coincides with State Health's secondary standard (NAC 445A.455) for public water systems. While public water systems are not required to meet secondary standards, they are required to notify the public of secondary standard exceedances if other more suitable, economically feasible water supplies are available. As a secondary standard constituent, TDS is regulated because it is more of an aesthetic and operational concern rather than a health hazard. Elevated TDS levels may cause the water to be corrosive, salty or brackish taste, result in scale formation, and interfere and decrease efficiency of hot water heaters. Therefore for the purposes of this TMDL, the TDS target is set at 500 mg/l.

3.9.4 Pollutant Load Capacity and Allocation: The TDS Load Capacity or TMDL for Mill Creek (for any given flow) is represented by the following equation:

$$TMDL\ (lbs/day) = Water\ Quality\ Target \times Flow \times 5.39 \quad (Eq.\ 15)$$

Where:

Water quality target = 500 mg/l
Flow = streamflow at water quality monitoring site
5.39 = conversion factor

This TMDL applies any monitoring site on Mill Creek. While no continuous flow measurements occur on Mill Creek, RTWG has been taking streamflow measurements to coincide with the water quality sampling.

It is recognized that major TDS loading is coming from various sources within the Rio Tinto Mine site and the watershed. Therefore, a gross load allocation that accounts for all these sources has been set and is represented by the following equation:

$$\text{Load Allocation (lbs/day)} = \text{TMDL (lbs/day)} \qquad \text{(Eq. 16)}$$

No explicit margin of safety is needed in this equation. As previously discussed, TMDLs are to include a margin of safety to account for uncertainties in meeting the water quality standards when the target and TMDL are met. Through Equation 15, the TMDL is directly related to the water quality standard with no uncertainty in this relationship. While there is uncertainty in the flow data, this uncertainty impacts both sides of Equation 15 equally.

The TMDL is intended to reflect adequate water quality needs across the entire range of flows rather than at a single flow, i.e. average flow. This has been accomplished through the use of the above equations whereby seasonal affects and critical conditions can be considered.

In some instances, TMDL reports present estimates of load reductions needed for compliance with the load allocations. However, this is not plausible for the Mill Creek TMDL. There are insufficient data to accurately calculate historic loads and associated load reductions. However it can be stated that for TMDL compliance, load reductions are needed such that actual loads are at or below the Load Allocation (from Equation 16) at least 90% of the time[14]. In the absence of flow data, the TMDL is considered to be complied with when the TDS levels are below the target (500 mg/l) at least 90% of the time.

3.9.5 Future Needs: Following are future needs that have been identified for the phased TDS TMDL and related activities:

- The appropriateness of "municipal or domestic supply" as a beneficial use for Mill Creek is questionable. Mill Creek is not currently used as a municipal or domestic drinking water source and its potential for that use is limited given the impacts of Rio Tinto Mine. BWQP may need to consider undertaking a Use Attainability Analysis for this use on Mill Creek.

- There is insufficient information to accurately estimate TDS loads from the Rio Tinto area and the remainder of the watershed. Additional work is needed to quantify historic loading and load reductions.

[14] As described in Nevada's 2002 303(d) List, waters are identified as impaired when the water quality standards are exceeded in more than 10% of the samples.

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Appendix

Water Quality and Quantity Data at Selected Monitoring Stations

Table A-1: NDEP-BWQP Select Water Quality Data Below Wildhorse Reservoir (E12)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	USGS #13174500 Flow cu ft/sec
3/26/96		6.00	9.90	8.12	18.00	62.00	34.00	31.00	0.10	< 0.001	0.02	0.79		0.80
4/24/1996														
5/1/1996														
6/1/1996														
7/24/1996	15.10		7.90	8.29	5.20	134.00	10.00	73.00	0.11	< 0.001	<0.005	0.26		126.00
8/1/1996														
9/24/96	14.00		8.70	8.20	5.20	139.00	6.00	78.00	0.14	< 0.001	0.01	0.33		17.00
10/21/1996														
11/1/1996														
12/1/1996														
1/29/1997														
2/1/1997														
3/25/97		3.50	11.60	7.93	6.80	129.00	6.00	73.00	0.10	< 0.001	0.01	0.42		120.00
4/23/1997														
5/1/1997														
6/1/1997														
7/17/1997	17.40		9.00	8.47	5.40	87.00	5.00	53.00	0.07	< 0.001	0.02	0.64		43.00
8/1/1997														
9/23/97	17.70													74.00
10/23/1997														
11/1/1997														
12/1/1997														
1/21/1998														
2/1/1998														
3/24/98		4.80	7.90	8.79	4.80	104.00	5.00	24.00	0.28	< 0.001	0.00	3.19		0.00
4/14/1998														
5/1/1998														
6/1/1998														
7/20/1998			11.70	7.68	35.00	71.00	54.00	67.00	0.18	< 0.001	0.00	0.39		28.00
8/1/1998						133.00	10.00		0.03					
9/22/98	15.70		7.70	8.10		140.00	10.00		0.19					78.00
10/22/1998														
11/1/1998														
12/1/1998														
1/25/1999														
2/1/1999														

Table A-1: NDEP-BWQP Select Water Quality Data Below Wildhorse Reservoir (E12)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	USGS #13174500 Flow cu ft/sec
3/23/99								28.00		< 0.001	0.00	0.63	0.01	
4/1/1999														
5/2/1999														
6/23/1999														
7/6/99	13.20		9.41	8.17	9.10	118.00	4.00	71.00	0.08	< 0.001	0.01	0.50		83.00
8/1/99														
9/21/99	16.30		6.88	8.31	3.70	119.00	13.00		0.15					89.00
10/20/1999														
11/1/1999														
12/1/1999														
1/31/2000														
2/1/2000														
3/21/00														0.07
4/25/2000														
5/1/2000														
6/1/00														
7/25/2000	16.10		8.20	7.50	7.20	133.00	7.00	73.00	0.08	< 0.001	0.00	0.55	0.01	99.00
8/1/2000														
9/19/00	17.20		8.80	8.51	4.60	125.00	7.00	78.00	0.14	< 0.001	0.01	0.53	0.01	21.00
10/23/2000														
11/1/2000														
12/4/2000														
1/27/2001														
2/27/2001														
3/28/2001														
4/24/2001		4.30	10.45	7.63	6.30	47.00	3.00	19.00	0.02	< 0.001	0.00	0.39	0.00	0.01
5/23/2001														
6/7/2001														
7/17/2001	14.75		8.00	8.10	4.00	147.00	5.00	81.00	0.13	< 0.001	0.00	0.36	0.00	41.00
8/21/2001														
9/19/2001	10.00		15.80	9.10	8.10	163.00	9.00	78.00	0.16	< 0.001	0.00	0.42	0.00	4.40
10/24/2001														
11/28/2001														
12/19/2001														
Count	11		15	15	14	16	16	14	16	0	13	14	6	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	200 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed	0.00	0.00	0.00	0.00	7.00	0.00	13.00							

Table A-1: NDEP-BWQP Select Water Quality Data Below Wildhorse Reservoir (E12)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	USGS #13174500 Flow cu ft/sec
Std.														
Average	15.22	4.65	9.46	8.19	8.81	115.69	11.75	59.07	0.12		0.01	0.67	0.01	
Median	15.70	4.55	8.80	8.17	5.85	127.00	7.00	72.00	0.12		0.00	0.46	0.01	
Minimum	10.00	3.50	6.88	7.50	3.70	47.00	3.00	19.00	0.02		0.00	0.26	0.00	
Maximum	17.70	6.00	15.80	9.10	35.00	163.00	54.00	81.00	0.28		0.02	3.19	0.01	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.

Table A-2: NDEP-BWQP Select Water Quality Data Above Mill Creek (E4)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	USGS #13175100 Flow cu ft/sec
9/25/79										<0.001	<0.01	0.16		
6/28/88										<0.001	<0.005	0.43		
6/19/89	18.50		7.20		10.00	138.00	27.00		0.09	<0.001	0.010	0.23		
6/20/90	11.00		11.10		5.20	161.00	10.00		0.08	<0.001	<0.005	0.35		
7/31/91	25.00		9.70		4.10	156.00	7.00		0.15	<0.001	<0.005	0.23		
7/8/92	19.00		7.50	8.36	4.10	179.00	5.00	105.00	0.09	<0.001	<0.005	0.27		123
7/13/93	20.00		7.80		21.00	147.00	22.00	76.00	0.12	<0.001	<0.005	1.16		85
8/9/94	21.50		7.50	9.10	11.00	152.00	13.00	78.00	0.19	<0.001	0.010	0.60		88
3/28/95		5.00	9.90	8.23	13.00	111.00	28.00	65.00	0.09	<0.001	0.010	0.61		124
6/6/95	10.50		9.50	8.29	13.00	133.00	27.00	98.00	0.09	<0.001	0.010	0.55		259
9/13/1995	14.50		13.00		3.20	153.00	5.00	93.00	0.16	<0.001	<0.005	0.21		27
10/1/1995														
11/1/1995														
12/6/1995														
1/1/1996														
2/1/1996														
3/26/96		6.30	10.10	8.14	28.00	125.00	82.00	76.00	0.16	<0.001	0.010	1.12		
4/24/1996														
5/1/1996														
6/1/1996														
7/24/1996	18.00		7.80	8.21	6.60	134.00	24.00	76.00	0.02	<0.001	<0.005	0.41		
8/1/1996														
9/24/96	16.00		11.50	8.85	3.50	164.00	3.00	108.00	0.10	<0.001	0.010	0.25		
10/21/1996														

Table A-2: NDEP-BWQP Select Water Quality Data Above Mill Creek (E4)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	USGS #13175100 Flow cu ft/sec
11/1/1996														
12/1/1996														
1/29/1997														
2/1/1997														
3/25/97		8.30	11.00	8.00	39.30	116.00	68.00	66.00	0.16	<0.001	0.010	1.23		
4/23/1997														
5/1/1997														
6/1/1997														
7/17/1997	20.80		7.80	8.14	9.50	126.00	22.00	88.00	0.10	<0.001	0.002	0.94		71
8/1/1997														
9/23/97	17.00		8.80	8.44	4.50	115.00	6.00		0.25					86
10/23/1997														
11/1/1997														
12/1/1997														
1/21/1998														
2/1/1998														
3/24/98		5.30	11.30	7.84	227.00	131.00	332.00	95.00	0.43	0.00	0.027	23.40		428
4/14/1998														
5/1/1998														
6/1/1998														
7/20/1998						166.00	10.00		0.05					
8/1/1998														
9/22/98	16.80		9.60	8.60		145.00	10.00		0.30					100
10/22/1998														
11/1/1998														
12/1/1998														
1/25/1999														
2/1/1999														
3/23/99		6.90	18.20	8.00	20.20	128.00	26.00	79.00	0.13	<0.001	0.000	0.96	<0.001	188
4/1/1999														
5/2/1999														
6/23/1999														
7/6/99	19.20		9.09	8.60	9.40	145.00	8.00	88.00	0.07	<0.001	0.010	0.48	<0.001	120
8/1/99														
9/21/99	17.70		8.06	8.77	5.40	137.00	12.00		0.14					93
10/20/1999														
11/1/1999														
12/1/1999														

Table A-2: NDEP-BWQP Select Water Quality Data Above Mill Creek (E4)														
Date	Temperature °C May-Oct	Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	USGS #13175100 Flow cu ft/sec
1/31/2000														
2/1/2000														
3/21/00		7.70	21.24	8.23	22.00	155.00	43.00	96.00	0.13	<0.001	0.010	1.33	<0.001	85
4/25/2000														
5/1/2000														
6/1/00														
7/25/2000	19.00		8.80	7.60	7.00	140.00	4.00	83.00	0.06	<0.001	0.000	0.42	<0.001	99
8/1/2000														
9/19/00	17.10		12.40	9.03	3.80	126.00	7.00	96.00	0.10	<0.001	0.010	0.28	<0.001	26
10/23/2000														
11/1/2000														
12/4/2000														
1/27/2001														
2/27/2001														
3/28/2001														
4/24/2001		5.10	10.94	8.22	13.00	108.00	19.00	74.00	0.06	<0.001	0.000	0.96	<0.001	173
5/23/2001														
6/7/2001														
7/17/2001	21.90	7.60	8.36	3.70		153.00	6.00	105.00	0.09	0.00	0.000	0.32	0.00	55
8/21/2001														
9/19/2001	17.80	9.40	8.70	8.70		177.00	15.00	105.00	0.10	0.00	0.000	0.47	0.00	10
10/24/2001														
11/28/2001														
12/19/2001														
Count	20	4	26	21	25	27	27	20	27	21	17	27	6	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	200 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed Std.	14.00	75.00	0.00	0.00	44.00	0.00	32.00		48.00	0.00	0.00	19.00	0.00	
Average	15.95	7.60	10.26	8.37	19.90	141.52	32.84	87.50	0.13	0.002	0.008	1.45	0.002	
Median	17.80	7.30	9.55	8.29	9.40	140.00	15.00	88.00	0.10	0.002	0.010	0.45	0.004	
Minimum	5.00	5.10	7.20	7.60	3.20	108.00	3.00	65.00	0.02	0.001	0.001	0.16	0.000	
Maximum	25.00	10.50	21.24	9.10	227.00	179.00	332.00	108.00	0.43	0.002	0.027	23.40	0.010	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.

Table A-3: RTWG Select Water Quality Data Above Mill Creek (SW-3)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
9/25/79														
6/28/88														
6/19/89														
6/20/90														
7/31/91														
7/8/92														
7/13/93														
8/9/94														
3/28/95														
6/6/95														
9/13/1995	13.6		8.40	7.30	4.80	160	5	102	0.23	0.0005	0.010	0.51	<0.01	39.7
10/1/1995														
11/1/1995														
12/6/1995		5.1	9.90	7.00	8.80	190	5	140	0.06	0.0005	0.010	0.94	<0.01	27.2
1/1/1996														
2/1/1996														
3/26/96														
4/24/1996		11.1	10.00	6.70	27.00	100	56	57	0.06	0.0005	0.010	1.73	<0.01	236.4
5/1/1996														
6/1/1996														
7/24/1996	23.2		3.70	8.30	5.50	130	5	90	0.07	0.0005	0.002	0.64	0.001	130.8
8/1/1996														
9/24/96														
10/21/1996	6.4		10.90	7.50	5.40	170	12	123	0.07	0.0005	0.003	0.37	0.008	27.9
11/1/1996														
12/1/1996														
1/29/1997		5.8	7.50	7.80	8.90	140	12	92	0.07	0.0005	0.001	0.68	<0.001	78.6
2/1/1997														
3/25/97														
4/23/1997		6.4	4.00	7.50	49.20	100	62	51	0.10		0.010	3.46	0.01	
5/1/1997														
6/1/1997														
7/17/1997	16.6		8.80	8.00	7.00	150	38	91	0.04		0.007	1.25	0.001	163.4
8/1/1997														
9/23/97														
10/23/1997	6.9		9.30	8.10	2.10	180	5	133	0.04		0.001	0.38	0.002	28.6

Table A-3: RTWG Select Water Quality Data Above Mill Creek (SW-3)

Date	Temperature ^{o}C May-Oct	Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
11/1/1997														
12/1/1997														
1/21/1998		3.0		7.40	5.70	160	22	121	0.08		0.002	0.84	0.002	45.7
2/1/1998														
3/24/98														
4/14/1998		5.3	11.70	7.40	7.60	110	20	67	0.05		0.003	1.15	<0.001	147.9
5/1/1998														
6/1/1998														
7/20/1998	24.9		9.00	8.50	3.70	130	5	85	0.06		0.001	0.71	<0.001	168
8/1/1998	9.0		10.40	8.40	2.90	150	8	106	0.01		0.001	0.38	<0.001	48.9
9/22/98														
10/22/1998														
11/1/1998														
12/1/1998														
1/25/1999		1.1	8.80	7.50	7.30	160	6	109	0.07		0.002	0.84	<0.001	28.5
2/1/1999														
3/23/99														
4/1/1999														
5/2/1999	11.7		11.00	7.00	32.00	90	38	57	0.10		0.004	2.60	0.001	
6/23/1999	16.7		9.80	7.70	4.80	150	8	92	0.03		0.002	0.50	0.001	
7/6/99														
8/1/99														
9/21/99														
10/20/1999	10.7		11.10	7.90	1.80	180	5	148	0.03		0.001	0.26	0.002	22.25
11/1/1999														
12/1/1999														
1/31/2000		14.3	11.10	7.80	1.40	180	6	149	0.01		0.001	0.26	<0.001	19.07
2/1/2000														
3/21/00														
4/25/2000		11.3	7.60	7.10	14.30	100	14	53	0.03		0.001	1.16	<0.001	130.79
5/1/2000														
6/1/00														
7/25/2000	21.7		8.40	8.00	4.80	130	5	87	0.10		0.002	0.51	0.002	102.86
8/1/2000														
9/19/00														
10/23/2000	14.6		10.60	7.70	2.80	190	8	153	0.02		0.001	0.22	<0.001	6.18
11/1/2000														
12/4/2000		0.3	11.90	8.10	3.10	200	5	154	0.02		0.001	0.30	<0.001	20.69

Table A-3: RTWG Select Water Quality Data Above Mill Creek (SW-3)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
1/27/2001		0.1	8.60	7.30	1.80	180	6	150	0.02		0.001	0.18	<0.001	
2/27/2001		0.8	12.90	7.80	2.70	190	5	141	0.02		0.002	0.32	0.002	4.2
3/28/2001		4.6	10.20	7.10	20.10	160	26	87	0.13		0.003	1.81	0.003	121
4/24/2001		5.3	10.50	7.20	24.10	120	14	59	0.05		0.003	1.80	0.003	122
5/23/2001	13.2		9.30	7.00	23.10	140	34	81	0.11		0.002	0.85	0.002	149
6/7/2001	12.5		8.80	7.50	10.50	160	8	90	0.05		0.003	0.40	0.003	211
7/17/2001	17.1		7.20	8.00	1.90	170	10	112	0.09		0.001	0.28	<0.001	58.2
8/21/2001	17.3		9.10	7.90	2.60	150	5	91	0.11		0.001	0.41	<0.001	53.9
9/19/2001	12.3		8.10	7.60	3.90	170	6	117	0.05		0.001	0.44	<0.001	9.3
10/24/2001	6.7		9.40	7.30	6.40	200	5	126	0.07		0.001	0.47	<0.001	9.7
11/28/2001		0.6	17.80	7.50	2.70	230	5	174	0.03		0.001	0.38	<0.001	8
12/19/2001		0.4	18.30	7.60	1.30	200	5	156	0.01		0.001	0.20	<0.001	11.6
Count	18	16	33	34	34	34	34	34	34	6	34	34	15	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	200 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed Std.	16.00	18.00	7.32	0.00	22.00	0.00	17.00		17.00	0.00	0.00	22.00	0.00	
Average	14.17	4.72	9.82	7.60	9.18	156.47	14.09	107.18	0.06	0.0005	0.003	0.80	0.003	
Median	13.40	4.85	9.40	7.55	5.10	160.00	7.00	104.00	0.06	0.0005	0.002	0.51	0.002	
Minimum	6.40	0.10	3.70	6.70	1.30	90.00	5.00	51.00	0.01	0.0005	0.001	0.18	0.001	
Maximum	24.90	14.30	18.30	8.50	49.20	230.00	62.00	174.00	0.23	0.0005	0.010	3.46	0.010	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.

Table A-4: NDEP-BWQP Select Water Quality Data Mill Creek (E14)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
3/25/97				7.38										
4/23/1997														
5/1/1997														
6/1/1997														
7/17/1997														
8/1/1997														
9/23/97	18		6	2.96	40	1231	25	38	0.02		0.140	1.56	18	
10/23/1997														
11/1/1997														

Table A-4: NDEP-BWQP Select Water Quality Data Mill Creek (E14)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
12/1/1997														
1/21/1998														
2/1/1998														
3/24/98		3.8	12	7.87	116	107	202	107	0.33		0.402	6.19		
4/14/1998														
5/1/1998														
6/1/1998														
7/20/1998						136	10	53	0.05		0.275	13.80		
8/1/1998														
9/22/98	15.9		7.6	4.70		908	71	86	0.30		0.138	3.78		
10/22/1998			5.31											
11/1/1998														
12/1/1998														
1/25/1999														
2/1/1999														
3/23/99		7		8.00	57.1	141	88	424	0.15	0.009	3.110	74.20	2.480	
4/1/1999														
5/2/1999														
6/23/1999														
7/6/99	21.9		7.82	8.28	18.9	133	16		0.07			7.45		
8/1/99														
9/21/99	17.1		5.92	4.01	387	1105	62	89	0.04	0.001	0.920	4.27	0.110	
10/20/1999														
11/1/1999														
12/1/1999														
1/31/2000														
2/1/2000														
3/21/00		6.2	18.8	6.79	60	163	88	88	0.14	0.001	0.190		0.080	
4/25/2000														
5/1/2000														
6/1/00														
7/25/2000	23		6.6	3.10	260	604	68		0.02			9.20		
8/1/2000														
9/19/00	21		5.6	2.99	90	1130	90	94	0.00	0.002	1.120	48.20	0.030	
10/23/2000														
11/1/2000														
12/4/2000														
1/27/2001														

Table A-4: NDEP-BWQP Select Water Quality Data Mill Creek (E14)

Date	Temperature °C May-Oct	Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
2/27/2001														
3/28/2001														
4/24/2001		3.4	10.49	7.00	28	99	16	336	0.08	0.009	3.230	73.20	2.100	
5/23/2001														
6/7/2001														
7/17/2001	26		6.45	7.74	110	388	48	639	0.04	0.019	7.500	6.45	7.400	
8/21/2001														
9/19/2001	31		8.5	3.10	20	1060	24	42	0.09	0.001	0.280	15.77	0.190	
10/24/2001														
11/28/2001														
12/19/2001														
Count	8	4	12	13	11	13	13	11	13	7	11	12	7	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	250 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed Std.	50.00	25.00	25.00	66.66	100.00	46.00	69.23		30.77	42.86	77.00	100.00	100.00	
Average	21.74	5.10	8.42	5.69	107.91	554.23	62.15	181.45	0.10	0.006	1.57	22.01	1.77	
Median	21.45	5.00	7.10	6.79	60.00	388.00	62.00	89.00	0.07	0.002	0.40	8.33	0.19	
Minimum	15.90	3.40	5.31	2.96	18.90	99.00	10.00	38.00	0.02	0.001	0.14	1.56	0.03	
Maximum	31.00	7.00	18.80	8.28	387.00	1231.00	202.00	639.00	0.33	0.019	7.50	74.20	7.40	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.

Table A-5: RTWG Select Water Quality Data Mill Creek (SW-2)

Date	Temperature °C May-Oct	Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
10/1/1995			6.30											
11/1/1995			9.10											
12/6/1995		4.90	9.30	4.00	48	510.00	60	267.00	0.13	0.004	5.13	25.50	5.04	2.100
1/1/1996			12.00											
2/1/1996			10.70											
3/26/96			9.90											
4/24/1996		5.30	9.60	6.15	36	85.00	52	37.00	0.12	0.001	0.21	3.81	0.07	68.600
5/1/1996			8.30											
6/1/1996			3.00											
7/24/1996	23.00		2.70	4.00	46	410.00	16	237.00	0.01	0.001	1.15	14.00	0.84	0.100

Table A-5: RTWG Select Water Quality Data Mill Creek (SW-2)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
8/1/1996														
9/24/96														
10/21/1996	2.30		11.30	4.30	18	800.00	8	484.00		0.003	2.70	12.30	2.73	0.800
11/1/1996														
12/1/1996														
1/29/1997		1.90	8.80	4.70	88	270.00	92	133.00	0.14	0.010	2.25	23.20	2.00	7.800
2/1/1997														
3/25/97														
4/23/1997		6.20	7.50	6.40	45	80.00	58	31.00	0.09	0.003	0.21	6.22	0.06	0.000
5/1/1997														
6/1/1997														
7/17/1997	19.20		7.40	7.20	25	230.00	28	144.00	0.01		0.26	6.69	0.02	0.700
8/1/1997														
9/23/97														
10/23/1997	5.90		10.20	5.90	11	490.00	186	342.00	0.15		0.92	41.10	0.01	1.100
11/1/1997														
12/1/1997														
1/21/1998		0.40		6.60	11	155.00	42	122.00	0.02		0.29	6.61	0.01	2.600
2/1/1998														
3/24/98														
4/14/1998		5.20	12.30	6.80	14	100.00	5	42.00	0.05		0.10	2.69	0.01	25.900
5/1/1998														
6/1/1998														
7/20/1998	25.70		8.00	8.00	34	190.00	14	132.00	0.03		0.21	8.80	0.07	1.400
8/1/1998														
9/22/98														
10/22/1998	8.90		8.10	6.60	198	320.00	114	207.00	0.01		0.07	42.90	0.01	0.400
11/1/1998														
12/1/1998														
1/25/1999		1.10	9.80	7.10	92	190.00	46	135.00	0.03		0.76	17.00	0.04	3.900
2/1/1999														
3/23/99														
4/1/1999														
5/2/1999	13.70		11.90	6.50	60	120.00	64	39.00	0.14		0.31	4.39	0.01	0.000
6/23/1999	18.00		8.90	7.10	8	100.00	5	57.00	0.03		0.07	2.09	0.14	16.700
7/6/99														
8/1/99														
9/21/99														

Table A-5: RTWG Select Water Quality Data Mill Creek (SW-2)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
10/20/1999	12.50		11.80	6.50	120	410.00	46	267.00	0.01		1.58	30.60	0.04	0.580
11/1/1999														
12/1/1999														
1/31/2000		1.10	11.20	6.30	85	265.00	44	175.00	0.01		0.91	17.70	0.03	2.020
2/1/2000														
3/21/00														
4/25/2000	12.60		7.80	6.60	12	80.00	10	30.00	0.01		0.05	2.05	0.02	33.000
5/1/2000														
6/1/00														
7/25/2000	23.30		6.50	3.40	115	900.00	52	494.00	0.01		4.50	45.90	0.04	0.050
8/1/2000														
9/19/00														
10/23/2000	15.40		9.40	5.65	108	395.00	58	241.00	0.01		1.12	18.50	4.50	0.440
11/1/2000														
12/4/2000		0.10	12.30	6.10	118	305.00	52	190.00	0.02		1.07	25.70	0.23	0.580
1/27/2001		0.10	8.30	4.90	69	270.00	37	186.00	0.01		0.83	15.65	0.14	0.000
2/27/2001		0.00	11.90	6.65	300	605.00	90	300.00	0.03		2.35	70.80	0.02	1.200
3/28/2001		4.60	10.90	6.65	26	125.00	8	48.00	0.09		0.18	3.11	1.16	27.100
4/24/2001		7.30	10.20	6.90	22	100.00	5	35.00	0.04		0.10	3.04	0.10	29.500
5/23/2001	16.10		8.20	6.60	13	140.00	10	46.00	0.08		0.11	1.96	0.07	12.800
6/7/2001	13.60		9.40	7.50	14	310.00	5	75.00	0.04		0.28	4.04	0.03	4.800
7/17/2001	20.60		5.20	5.40	23	515.00	16	356.00	0.01		0.24	3.78	0.03	0.014
8/21/2001	18.40			6.00	198	3700.00	86	2500.00	0.02		1.83	28.10	0.37	0.000
9/19/2001	10.80		5.10	6.00	1	860.00	8	587.00	0.02		0.15	0.24	0.12	0.002
10/24/2001	6.70		6.00	6.00	0	1000.00	5	669.00	0.03		0.09	0.12	0.11	0.009
11/28/2001		0.10	18.10	5.30	137	540.00	66	316.00	0.03		2.10	35.40	0.65	0.800
12/19/2001														
Count	18	14	37	32	32	32	32	32	31	6	32	32	32	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	250 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed Std.	16.67	7.14	10.81	59.38	90.63	59.38	59.38		16.13	16.67	71.88	93.75	9.00	
Average	14.82	2.74	9.12	6.06	65.41	455.31	43.38	278.88	0.05	0.0036	1.00	16.37	0.58	
Median	14.55	1.50	9.30	6.35	40.35	287.50	43.00	180.50	0.03	0.0028	0.30	10.55	0.07	
Minimum	2.30	0.00	2.70	3.40	0.30	80.00	5.00	30.00	0.01	0.0010	0.05	0.12	0.01	
Maximum	25.70	7.30	18.10	8.00	300.00	3700.00	186.00	2500.00	0.15	0.0100	5.13	70.80	5.04	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.

Table A-6: NDEP-BWQP Select Water Quality Data Below Mill Creek (E15)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
1/31/2000														
2/1/2000														
3/21/00		7.2	18.76	7.9	21	158	30	96	0.10	0.001	0.13	1.72	<0.04	
4/25/2000														
5/1/2000														
6/1/00														
7/25/2000	18.75		8	9.5	8	147	4	81	0.06	0.001	0.01	0.06	<0.01	
8/1/2000														
9/19/00	18.4		9.1	8.86	3.2	135	10	100	0.09	0.001	0.01	0.37	<0.01	
10/23/2000														
11/1/2000														
12/4/2000														
1/27/2001														
2/27/2001														
3/28/2001														
4/24/2001		4.1	11.01	7.95	17	105	18	66	0.05	0.001	0.07	2.28	0.05	
5/23/2001														
6/7/2001														
7/17/2001	21		8.4	8.21	4.2	177	5	107	0.07	0.002	0.01	0.36	<0.01	
8/21/2001														
9/19/2001	17		8.8	8.9	3.8	179	7	102	0.12	0.001	0	0.32	0.01	
10/24/2001														
11/28/2001		7.2	18.76	7.9	21	158	30	96	0.10	0.001	0.13	1.72	<0.04	
12/19/2001														
Count	4	2	6	6	6	6	6	6	6	6	6	6	2	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	250 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed Std.	25.00	50.00	0.00	0.00	33.33	0.00	50.00		33.33	0.00	0.00	33.33	0.00	
Average	18.79	5.65	10.68	8.55	9.53	150.17	12.33	92.00	0.08	0.0012	0.04	0.85	0.030	
Median	18.58	5.65	8.95	8.54	6.10	152.50	8.50	98.00	0.08	0.0010	0.01	0.37	0.030	
Minimum	17.00	4.10	8.00	7.90	3.20	105.00	4.00	66.00	0.05	0.0010	0.00	0.06	0.010	
Maximum	21.00	7.20	18.76	9.50	21.00	179.00	30.00	107.00	0.12	0.0020	0.13	2.28	0.050	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.

Table A-7: RTWG Select Water Quality Data Below Mill Creek (SW-4)

Date	Temperature °C May-Oct	Temperature °C Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
10/1/1995			6.30											
11/1/1995			9.10											
12/6/1995		4.90	9.30	4.00	48	510.00	60	267.00	0.13	0.004	5.13	25.50	5.04	2.100
1/1/1996			12.00											
2/1/1996			10.70											
3/26/96			9.90											
4/24/1996		5.30	9.60	6.15	36	85.00	52	37.00	0.12	0.001	0.21	3.81	0.07	68.600
5/1/1996			8.30											
6/1/1996			3.00											
7/24/1996	23.00		2.70	4.00	46	410.00	16	237.00	0.01	0.001	1.15	14.00	0.84	0.100
8/1/1996														
9/24/96														
10/21/1996	2.30		11.30	4.30	18	800.00	8	484.00		0.003	2.70	12.30	2.73	0.800
11/1/1996														
12/1/1996														
1/29/1997		1.90	8.80	4.70	88	270.00	92	133.00	0.14	0.010	2.25	23.20	2.00	7.800
2/1/1997														
3/25/97														
4/23/1997		6.20	7.50	6.40	45	80.00	58	31.00	0.09	0.003	0.21	6.22	0.06	0.000
5/1/1997														
6/1/1997														
7/17/1997	19.20		7.40	7.20	25	230.00	28	144.00	0.01		0.26	6.69	0.02	0.700
8/1/1997														
9/23/97														
10/23/1997	5.90		10.20	5.90	11	490.00	186	342.00	0.15		0.92	41.10	0.01	1.100
11/1/1997														
12/1/1997														
1/21/1998		0.40		6.60	11	155.00	42	122.00	0.02		0.29	6.61	0.01	2.600
2/1/1998														
3/24/98														
4/14/1998		4.60	12.7	8.1	9.90	110	18	59.00	0.05		0.025	1.63	0.003	158.0
5/1/1998														
6/1/1998														
7/20/1998	24.20		8.4	9	3.80	120	<5	86.00	0.06		0.005	0.64	0.01	176.0
8/1/1998														
9/22/98														
10/22/1998	9.20		7	8.5	4.50	150	14	110.00	<0.01		0.032	1.23	0.02	47.4
11/1/1998														

Table A-7: RTWG Select Water Quality Data Below Mill Creek (SW-4)

Date	Temperature °C May-Oct	Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
12/1/1998														
1/25/1999		0.90	9.4	7.6	27.00	165	18	118.00	0.07		0.16	4.33	<0.001	38.6
2/1/1999														
3/23/99														
4/1/1999														
5/2/1999	13.70		13.8	7.3	44.00	95	37	51.00	0.11		0.152	0.07	0.004	
6/23/1999	16.90		10	8.5	6.20	140	6	83.00	0.03		0.016	0.03	0.014	
7/6/99														
8/1/99														
9/21/99														
10/20/1999	11.30		7.4	8.4	5.00	190	<5	152.00	0.02		0.036	0.15	0.067	21.5
11/1/1999														
12/1/1999														
1/31/2000		12.10	11.1	7.9	6.60	200	<5	144.00	0.01		0.065	0.09	0.012	22.4
2/1/2000														
3/21/00														
4/25/2000		12.10	8	8.7	11.60	90	14	47.00	0.04		0.017	0.03	0.009	169.0
5/1/2000														
6/1/00														
7/25/2000	23.20		8.5	7	5.60	130	7	87.00	0.10		0.01	0.10	0.005	115.0
8/1/2000														
9/19/00														
10/23/2000	11.40		10.9	8.2	5.80	200	72	156.00	0.02		0.037	0.15	0.012	10.2
11/1/2000														
12/4/2000		0.50	12.7	7.7	11.50	200	<5	156.00	0.02		0.082	0.11	0.005	23.3
1/27/2001		0.10	9.09	6.9	6.50	180	<5	153.00	0.02		0.058	1.24	0.005	
2/27/2001		1.00	7.8	7.1	139.00	240	50	166.00	0.03		0.75	18.00	0.015	1.2
3/28/2001		4.00	10.1	6.8	22.00	150	32	79.00	0.10		0.029	1.95	0.017	27.1
4/24/2001		4.70	11.1	7.8	18.00	120	6	54.00	0.04		0.028	1.90	0.029	29.5
5/23/2001	14.80		9.1	7.6	21.50	160	34	78.00	0.10		0.012	0.96	0.009	12.8
6/7/2001	11.80		9	7.7	10.70	160	10	91.00	0.05		0.003	0.42	0.002	4.8
7/17/2001	17.00		8.6	8.7	2.00	160	8	111.00	0.09		0.0020	0.22	<0.001	0.0
8/21/2001	18.20		9.6	8.6	2.50	150	<5	91.00	0.10		0.0010	0.39	<0.001	0.0
9/19/2001	14.60		7.03	9.5	3.30	170	6	117.00	0.11		<0.001	0.50	<0.001	0.0
10/24/2001	5.50		10.14	7.3	6.20	190	<5	126.00	0.07		<0.001	0.57	<0.001	0.0
11/28/2001		0.20	14.85	8.8	8.60	240	6	182.00	0.03		0.0840	1.71	0.0090	0.8
12/19/2001		0.60	16.9	6.8	24.10	210	10	153.00	0.02		0.0980	5.64	0.0160	0.8

Table A-7: RTWG Select Water Quality Data Below Mill Creek (SW-4)

Date	Temperature °C May-Oct	Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaC0_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	Flow cu ft/sec
Count	18	16	33	33	34	34	26	34	32	6	31	34	28	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	250 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed Std.	22.22	18.75	9.09	3.03	41.18	0.00	34.62		21.00	0.00	3.230	44.00		
Average	14.99	3.90	9.55	7.99	16.59	160.29	22.35	107.50	0.06	0.0007	0.102	1.88	0.021	
Median	14.70	3.65	9.10	8.00	8.45	160.00	14.50	105.00	0.07	0.0006	0.036	0.84	0.011	
Minimum	3.40	0.10	3.60	6.80	2.00	90.00	6.00	36.00	0.01	0.0005	0.001	0.03	0.002	
Maximum	24.90	12.10	16.90	9.50	139.00	240.00	72.00	182.00	0.23	0.0010	0.890	18.00	0.080	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.

Table A-8: NDEP-BWQP Select Water Quality Data Below Slaughterhouse Creek (E16)

Date	**Temperature °C May-Oct**	**Nov-April**	**Dissolved O_2 mg/l**	**pH Field**	**Turbidity NTU**	**Tot. Dis. Solids mg/l**	**Tot. Susp. Solids mg/l**	**Hardness as $CaC0_3$ mg/l**	**Total P mg/l**	**Tot. Rec. Cd mg/l**	**Tot. Rec. Cu mg/l**	**Tot. Rec. Fe mg/l**	**Tot. Dis. Cu mg/l**	**USGS #13175100 Flow cu ft/sec**
1/31/2000														
2/1/2000														
3/21/00		6.5	22.19	8.03	26.00	155	47	88	0.14	<0.001	0.110	1.98	0.040	85.0
4/25/2000														
5/1/2000														
6/1/00														
7/25/2000	21.0		8.3	9.30	8.80	144	7	83	0.07	<0.001	0.010	0.47	0.010	21.0
8/1/2000														
9/19/00	18.0		9.2	8.78	4.00	135	8	101	0.1	<0.001	0.010	0.34	0.010	18.0
10/23/2000														
11/1/2000														
12/4/2000														
1/27/2001														
2/27/2001														
3/28/2001														
4/24/2001		4.0	11.7	7.99	17.00	108	26	66	0.05	<0.001	0.050	2.09	0.030	173.0
5/23/2001														
6/7/2001														
7/17/2001	21.5		6.5	8.67	3.90	177	7	107	0.08	0.002	0.010	0.37	0.010	21.5
8/21/2001														

Table A-8: NDEP-BWQP Select Water Quality Data Below Slaughterhouse Creek (E16)														
Date	Temperature °C May-Oct	Nov-April	Dissolved O_2 mg/l	pH Field	Turbidity NTU	Tot. Dis. Solids mg/l	Tot. Susp. Solids mg/l	Hardness as $CaCO_3$ mg/l	Total P mg/l	Tot. Rec. Cd mg/l	Tot. Rec. Cu mg/l	Tot. Rec. Fe mg/l	Tot. Dis. Cu mg/l	USGS #13175100 Flow cu ft/sec
9/19/2001	18.0		7.9	8.70	1.70	206	5	105	0.08	<0.001	0.010	0.17	0.010	18.0
10/24/2001														
11/28/2001														
12/19/2001														
Count	4	2	6	6	6	6	6	6	6	1	6	6	6	
Standard	21°C	7°C	6.00 mg/l	6.5-9.0	10 NTU	250 mg/l	25 mg/l		0.10 mg/l	0.005 mg/l	0.20 mg/l	1.00 mg/l	See Below	
% Exceed Std.	50.00	0.00	0.00	16.67	33.33	0.00	33.33		33.33	0.00	0.00	16.67	0.00	
Average	19.63	5.25	10.97	8.58	10.23	154.17	16.67	91.67	0.09	Less Than Detection Limit	0.033	0.90	0.018	
Median	19.50	5.25	8.75	8.69	6.40	149.50	7.50	94.50	0.08		0.010	0.42	0.010	
Minimum	18.00	4.00	6.50	7.99	1.70	108.00	5.00	66.00	0.05		0.010	0.17	0.010	
Maximum	21.50	6.50	22.19	9.30	26.00	206.00	47.00	107.00	0.14		0.110	2.09	0.040	

Note: Values reported as "Less Than Detection Limit" were not included in the average, median, minimum and maximum calculations. Total Dissolved Copper concentration is a function of Hardness: If Hardness = 50 mg/l, Standard =6 µg/l, If Hardness = 200 mg/l, Standard =18 µg/l.